Waveform Analyzing System

PM 3360

Operating Manual

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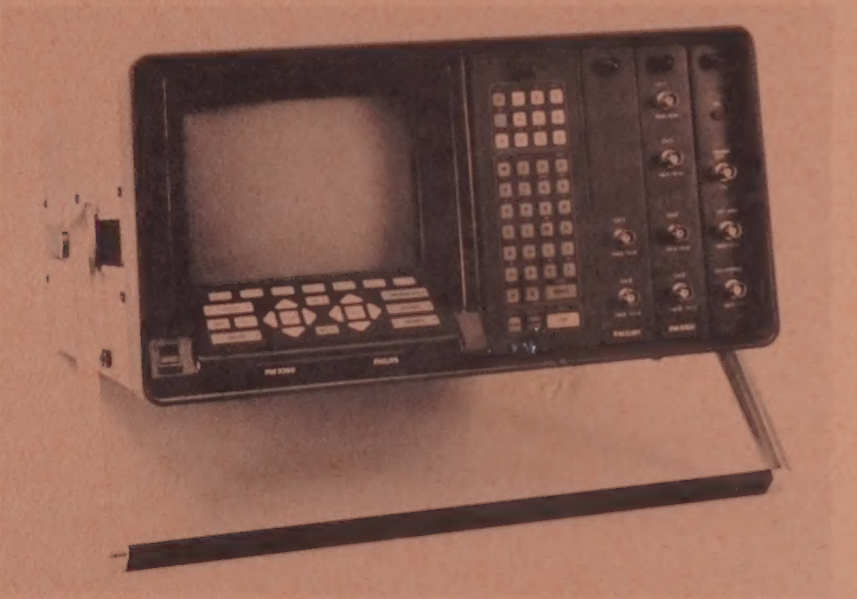
850701



PHILIPS

Waveform Analyzing System

PM 3360

Operating Manual

4822 872 00314
850701

Operating Manual for Waveform Analyzing System including mainframe, input modules and trigger manager.

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IMPORTANT

In correspondence concerning this instrument please quote the type number and serial number as given on the type plate.

NOTE The design of this instrument is subject to continuous development and improvement. Consequently, this instrument may incorporate minor changes in detail from the information contained in this manual.

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1. OPERATOR SAFETY

Read this page carefully before installation and use of the instrument.

1.1. INTRODUCTION

The instrument described in this manual is designed to be used by properly-trained personnel only. Adjustment, maintenance and repair of the exposed equipment shall be carried out only by qualified personnel.

1.2. SAFETY PRECAUTIONS

For the correct and safe use of this instrument it is essential that both operating and service personnel follow generally-accepted safety procedures in addition to the safety precautions specified in this manual. Specific warning and caution statements, where they apply, will be found throughout the manual. Where necessary, the warning and caution statements and/or symbols are marked on the apparatus.

1.3. CAUTION AND WARNING STATEMENTS

CAUTION: is used to indicate correct operating or maintenance procedures in order to prevent damage to or destruction of the equipment or other property.

WARNING: calls attention to a potential danger that requires correct procedures or practices in order to prevent personnel injury.

1.4. SYMBOLS

Read the operating instructions.

Protective earth(black) (grounding) terminal

1.5. IMPAIRED SAFETY PROTECTION

Whenever it is likely that safety-protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation. The matter should then be referred to qualified technicians. Safety protection is likely to be impaired if, for example, the instrument fails to perform the intended measurements or shows visible damage.

ARRANGEMENT OF MANUAL

This Operating Manual is arranged in such a way that the essential information on safety and operating procedures is immediately available in the first chapters.

You are strongly advised to read Section 3.2. SAFETY INSTRUCTIONS thoroughly before installing your oscilloscope.

In Chapter 4. OPERATING PROCEDURE, all the functions are clearly explained with help of illustrations. This procedure offers the possibility to operate the instrument immediately after installation.

Some programming facilities are explained at the end of chapter 4. More detailed programming information is given in a separate programming manual.

Complete information for preventive maintenance on the instrument can be found in Chapter 5. This is followed by details of the functional, mechanical and environmental data, listed in Chapter 6, Characteristics.

Finally, additional information regarding the various versions of the instrument and accesories is given in Chapter 7. and Chapter 8. respectively.

2. INTRODUCTION

This digital Oscilloscope is a revolutionary instrument in the field of digital oscilloscopes. It provides simultaneous four channels for digitizing, storing and processing waveforms. Programmability and IEEE-bus talk - listen capacibility allows total and partial systemization and data transfer for more extensive signal processing. One can use this oscilloscope in almost every area of engineering, science, production and testing.

Digital oscilloscopes, like the PM3360, are able to capture repetitive and transient signals by digitizing the signal with A/D-converters and storing the data in fast input buffer memories. Recorded data can be displayed, computed, stored etc. This technique offers many advantages in accuracy, resolution and repeatability never possible with analog scopes. Digital oscilloscopes outperform analog scopes in several points of view:

- With analog scopes it is rarely possible to capture useful pretrigger and posttrigger information. So it is difficult to find error signals responsible for troubles in your circuits or view signals a long time after trigger. This oscilloscope enables you to consider full pretrigger time or signal behaviour long after a trigger occured.

- Signal information is stored in the oscilloscope as long as you need it with no loss of intensity. Therefore it is easy to compare waveforms or record waveforms under same conditions. It is also possible to calculate waveforms out of recorded data like considering harmonic distortion etc.

- The oscilloscope is easy programmable either by using it´s internal computer power or controlling this instrument by a host computer like an IEEE-488 Controller. This enables a wide variety of signal processing, comparing etc. for making decisions. Data can be stored internal or external, hard copies can be made from waveforms and measurements for every trace displayed.

There is a wide spreaded field of applications where to use this oscilloscope.
In production and calibration of complex electronic and mechanical systems there are a lot of tests to perform with a very high degree of reliability which surely prohibit the use of manual methods. Because of the capability to store and recall measurement and calibration data like limits or adjustment values, new ways of rationalization of production testing are given.

Good examples are to be found in environmental long term testing on amplitude or frequency variations, on frequency contents, pulse width variations, correlations, energy contents etc.

There is also a strong need for these capabilities in development and research on all sorts of physical, electrical and mechanical phenomenas like electrol chemistry, fusion research, acoustics, ballistics studies, ultrasonics and all sorts of high voltage and high current transient analysis and electromagnetic interference problems in all fields of communication techniques.

In all these fields of engineering a solution is to be found for almost every measurement problem because of the lot of features the oscilloscope is offering, either for finding a special way how to cope with a new problem or for using the computing power of this instrument in automatic test systems, e.g. in reptitive measurement problems in production.

3. INSTALLATION INSTRUCTIONS

3.1. INITIAL INSPECTION

Check the contents of the shipment for completeness and note whether any damage has occured during transport. If the contents are incomplete, or there is damage, a claim should be filed with the carrier immediately, and the Philips Sales or Service organisation should be notified in order to facilitate the repair or replacement of the instrument.

3.2. SAFETY INSTRUCTIONS

3.2.1. Earthing

Before any connection to the input connectors is made, the instrument shall be connected to a protective earth conductor via the three-core mains cable; the mains plug shall be inserted only into a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension cord without protective conductor.

WARNING: Any interruption of the protective conductor inside or outside the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

When an instrument is brought from a cold into a warm environment, condensation may cause a hazardous condition. Therefore, make sure that the earthing requirements are strictly adhered to.

3.2.2. Mains voltage cord and fuses

Different power cords are available for the various local mains voltage outlets. The power cord version delivered is determined by the particular instrument version ordered (see also Chapter 7).

Note: If the mains plug has to be adapted to the local situation, such adaption should be done only by a qualified technician.

The oscilloscope is already adapted to the local mains voltage when it is received.
The voltage ranges are:

for 110V mains	90V ... 130V a.c. (r.m.s.)
220V mains	190V ... 250V a.c. (r.m.s.)
240V mains	205V ... 260V a.c. (r.m.s.)

IMPORTANT: adaption to another voltage is not possible.

WARNING: The instrument shall be disconnected from all voltage sources when renewing a fuse.

Mains fuse rating: 3.15 A. delayed-action for 220V and 240V range.
6.30 A. delayed-action for 110V range.

The mains fuseholders are located on the rear panel (see Fig. 3.1). If the mains fuses needs replacing, proceed as follows:
- remove power connections from the oscilloscope
- remove the fuseholder by means of a screwdriver or coin.
- fit a new fuse of the correct rating and refit the fuseholder.

WARNING: Make sure that only fuses of the required current and Voltage rating, and of the specified type, are used for renewal. The use of repaired fuses, and/or short-circuiting of the fuseholder, is prohibited.

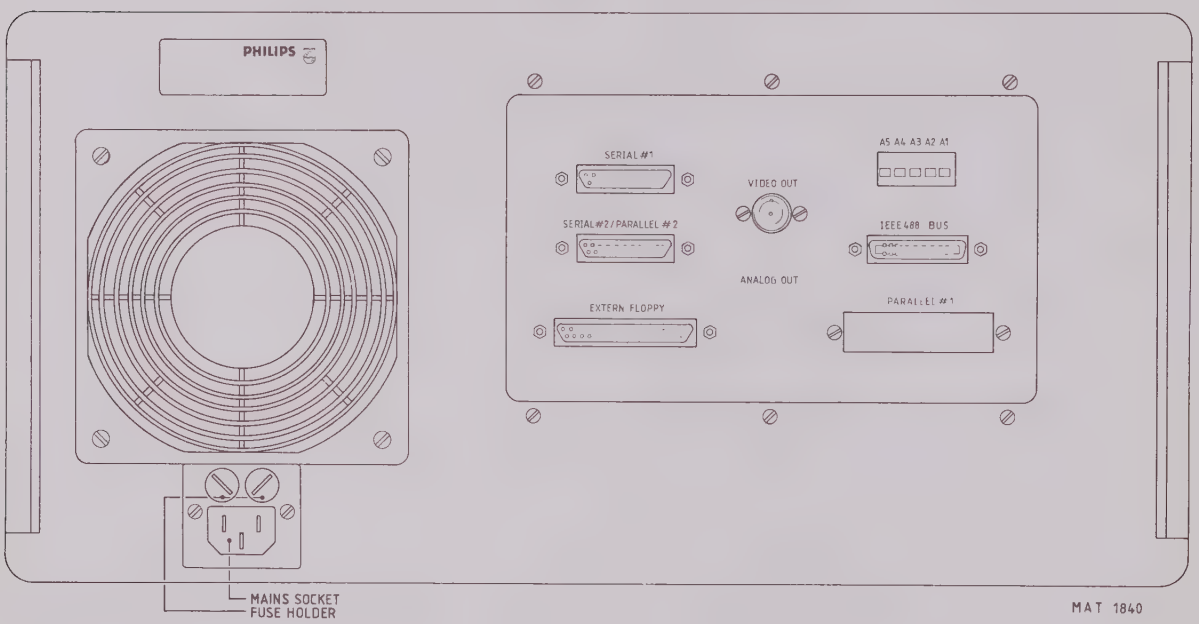


Fig. 3.1 Rear panel

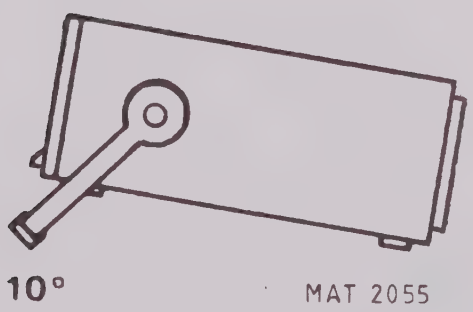
3.3. OPERATING POSITION OF THE INSTRUMENT

The oscilloscope may be used in the following positions

- horizontally on its bottom feet;
- vertically on its rear feet;
- on the carrying handle in three sloping positions (see Fig. 3.2) The available oscilloscope angles with respect to the working surface are 0^{o}, 10^{o} and 20^{o}C selected after pulling the carrying handle arms outwards and rotating.

The characteristics given in Chapter 6 are fully guaranteed for all the above-mentioned positions.

ATTENTION: - Ensure that the ventilation holes in the covers are free from obstruction, expecially at the rear because of the fan.
- Do not position the oscilloscope on any surface which radiates heat, or in direct sunlight.



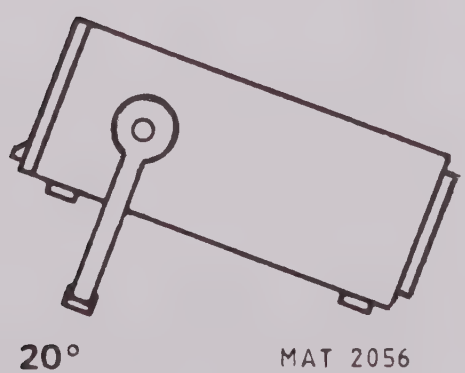


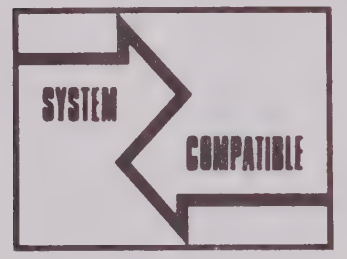
Fig. 3.2 Operating positions of PM3360

3.4. INTERFACES

3.4.1. IEEE 488/IEC 625 bus interface

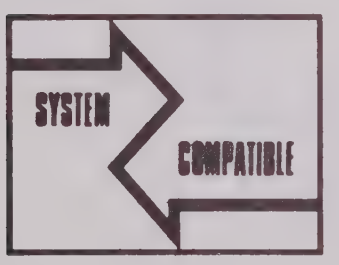
If your oscilloscope is equipped with an IEEE 488/IEC 625 bus option, it can be used in a bus system configuration.
More detailed information regarding this option is given in a separate programming book:

3.4.2. RS232/V24 bus interface



The RS232/V24 interface option offers the possibility to connect p.e. a printer with serial interface or an ASCII keyboard, as an output device or input device.

3.4.3. Centronic interface



The centronic interface is a parallel interface which can be used as output only, p.e. to connect a parallel printer.

OPERATING INSTRUCTIONS 4

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DIRECT MODE 4.2

SET MODE 4.3

MENU MODE 4.4

MONITOR MODE 4.5

HELP FUNCTIONS 4.6

ADVANCED MATHEMATICAL SOFTWARE 4.7

TECHNICAL DESCRIPTION 4.8

4. OPERATING INSTRUCTIONS

4.1. GENERAL DESCRIPTION

The PM3360 system is operated either manually or controlled by means of an external computer, e.g. via an IEEE-488 interface. There is also another way by programming the instrument using an ASCII keyboard under support of the programming capability in BASIC language (see section 4.5 and for details see programming manual).

Operating the PM3360 in the normal manual way is to be done by use of the two keyboards of the instrument.

On keyboard #1, which is mounted below the screen, there are keys for certain parameters like attenuation, zoom etc. With these keys the parameter values can be changed continuously by pressing the +or- side of the key. Keys referring to channels are painted light-brown, keys reffering to traces are painted beige. These dedicated keys are provided for adjustment of Trigger Level (TRIGGER LEV) attenuation (ATT), sampling rate (SAMPLE), zooming (ZOOM), position (POS), delay (DELAY), cursor (CURSOR) and reference cursor (REF). You will also find a SET-key and seven softkeys which are painted blue. The SET key is used for immediate input of parameters, selecting special variables, for which no dedicated keys exist etc. (see later). Softkeys are mounted directly below the screen and are relabled on every selected level of instrument operation (Fig. 4.1).

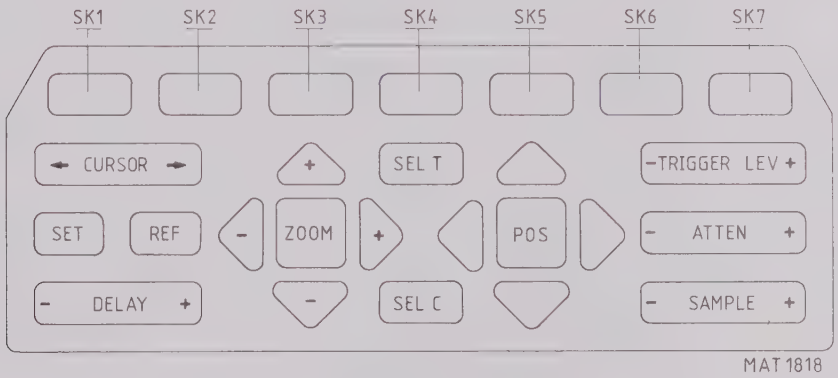


Fig. 4.1 Keyboard #1 (SK = softkeys 1 ... 7)

Keyboard #2 is used for input of parameter values, characters, operators etc. in alphanumerical form. It contains all normal ASCII keyboard elements completed by special characters, operators and functions (Fig. 4.2).

Special characters μ, Ω, π, ℓ can be used as part of variable names etc.

Special operators are the logic operators AND, OR and NOT (written as $\wedge$, $\vee$ and $\neg$)

A special function is the HTL-(Halt) function. Pressing 2nd and HTL stops the screen-picture updating. This capability is very useful for making plots of the screen picture by use of e.g. a video printer. Pressing any other key of keyboard #2 restart the updating. Keyboard status can be observed on the upper, right corner of the screen and can be changed as following:

Every normal typewriter offers the possibility to lock the keyboard for capital letters. The PM3360 keyboard #2 can be locked for letters (LLOCK) as well as capital letters (ULOCK). Status can be toggled between LLOCK and ULOCK by pressing 2nd and LOCK.

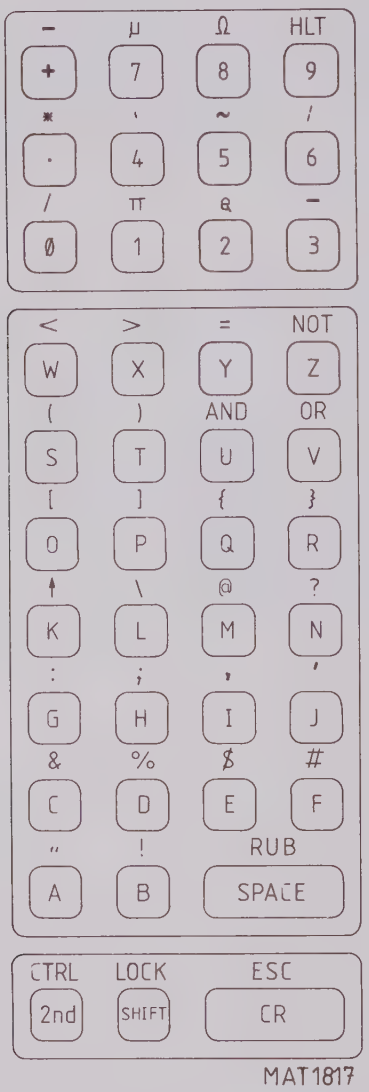


Fig. 4.2 Keyboard #2

If the actual status is ULOCK and one pressing the SHIFT key, status is changed to LOWER for the following keystroke and then returns to UNLOCK. If the actual status is LLOCK and one presses the SHIFT key, status is changed to UPPER for the following keystroke and then returns to LLOCK.

If one presses the 2nd key twice, keyboard status is changed to CTRL for the following keystroke.

In the technical description, you learne about the hard- and software components of the instrument, especially about the parameters that are to be set for operating the PM3360. This Section gives a detailed explanation about the three modes of operation and which values can be entered.

As mentioned above by operating the PM3360 one distinguishes between parameters referring to channels and those referring to traces. Parameters can be changed or set to a specified value in four different kinds of operating.
First, there are special keys on the instrument with which parameters can be adjusted in +or-direction continuously, e.g. incremented or decremented: this is called DIRECT mode.
Secondly in SET mode, by using the SET key, there is a choice of parameters like interpolation, color, offset etc. labeled on the soft keys (row of seven blue keys directly underneath the screen). By pressing the selected parameter you want to change, you can find a choice of values relabeled on the soft keys. This is also possible with parameters for which dedicated keys exist, the way of operation is: Press the SET key first, after that the dedicated key like zoom, attenuation etc. and finally the appropriate value out of those displayed for the softkeys. This is a very useful way of operation. You can easily set the parameters to specific values without changing to MENU mode or even different levels in a menu. A comparison with similar instruments shows that only PM3360 offers this feature for more convenient operation.

The third way of operating the PM3360 is the usual method of programming instrument via menues. There you get the whole set of parameters offered on the display for comparisons and decisions, what values may be selected, what can be done by entering specific values or characters by means of keyboard #2.

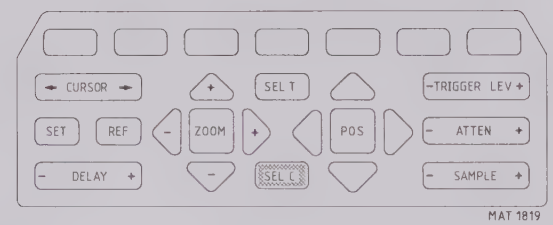
The fourth way of operating the PM3360 one could call the "MONITOR Mode", because all the internal or external programmins has to be done out of the external programming has to be done out of the Monitor program. This includes also all the transfers like from Memory to Floppy, or screen to printer etc.

Programming the instrument by means of the internal programming capability, using keyboard #2, is possible, but, by shure, a bit uncomfortable. Therefore it is recommended for this way of operation to use the adapted ASCII keyboard option and an RS 232 interface.

4.2. DIRECT MODE

4.2.1. Channels

Input channels are labelled as CH1L, CH2L, CH1R, CH2R (channel 1 left module, channel two left module, channel 2 right module), a specific input channel is selected by pressing the "select channel"-key on keyboard #1.



By having done this, the input channel names are to be found above the soft keys (Fig 4.3) and by pressing the selected one, all channel parameters adjusting keys are assigned to this one. The selected channel is indicated by flashing field in the display. Having pressed the key labelled CANCEL, no channel will be selected and no parameter changing of any channel is possible. If one nevertheless tries to do this, a visual as well as an acoustic warning will be given.

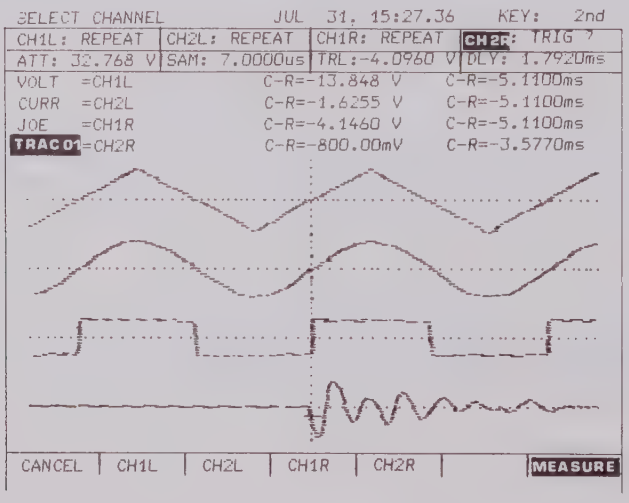


Fig. 4.3 Select channel

Each input channel is established with an attenuation network, a coupling circuit, an offset circuit, a sample counter, a delay counter, a buffer memory address counter and a digital adjustable trigger circuit.

In DIRECT mode of operation, there are keys for attenuation, sample rate, delay and trigger level. These parameters can be altered in +or- direction which means that the parameter value can be incremented or decremented. The actual value of these four parameters of the selected channel can be observed in the parameter line on the screen.

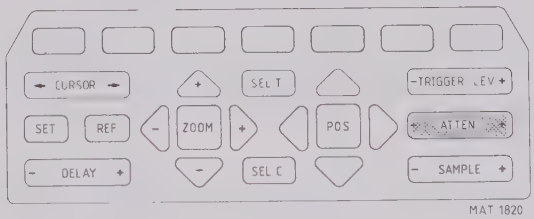
The numbers there will have the same color as the waveform which is displayed on the screen, if valid image is to be seen otherwise, the color will be cyan anyway.

This should be made clearer by an example: Record a certain signal in repeat mode (by pressing REPEAT softkey), e.g. a sine wave, pass over the single shot by pressing the corresponding softkey. The ENAB? sign in the channel status line, asking for enabling of the recording, will be shown . Change now any of the four parameters and you will find them being painted cyan. This means that what you can now see on the screen has not been recorded under present conditions. If you now press the ENABLE softkey and actual recording will be performed and the parameter values will be presented in the same colour as the waveform.

Other operations referring to channels are to change coupling, offsetting the base line, define a probe attenuation factor or define recording depth. These parameters are to be changed in SET mode and/or MENU mode.

4.2.1.1. Input attenuation

MAT 1820



Normally, there are 11 ranges of attenuation. Rather than with analog scopes, with digital scopes you do not consider an assignment of e.g. volts/div but a full range converting scale of the A/D converter. Therefore attenuation is defined as the full scale of the usable range symmetrical around zero, that means

2,048V means a converting range of roughly +/-1,024V

The input ranges differ stepwise by a factor of two, but remember what has been said in section 5.2 about representation of the digital word in two´s complement, so the actual range in the example given above will be

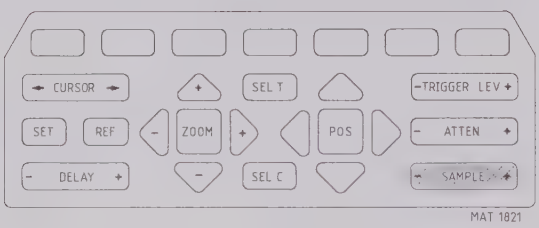
-1,024V to +1,024V - LSB

Attenuation value	Converting Range
128 mV	-64 mV to +64 mV - LSB
256 mV	-128 mV to +128 mV - LSB
512 mV	-256 mV to +256 mV - LSB
1,024 V	-512 mV to +512 mV - LSB
2,048 V	-1,024 V to +1,024 V - LSB
4,096 V	-2,048 V to +2,048 V - LSB
8,192 V	-4,096 V to +4,096 V - LSB
16,348 V	-8,192 V to +8,192 V - LSB
32,768 V	-16,348 V to +16,348 V - LSB
65,536 V	-32,768 V to +32,768 V - LSB
131,072 V	-65,536 V to +65,536 V - LSB

List of converting ranges (PM3361, PM3363)
(smallest attenuation value for PM3362 is 512mV)
The actual value of the LSB depends on the ADC used.

By pressing attenuation key on the "+ side" you will select the next more sensitive range and this leads to a bigger image, by pressing "- side" you select the next less sensitive range, and this leads to a smaller image on the screen. Keep in mind that the trigger level keeps its position in the range therefore changes its level accordingly. For effect of attenuation refer to Fig. 4.4.

4.2.1.2. Sample Rate



Pressing the +or- side of the SAMPLE key, sample rate becomes higher or vice versa. This leads to an image with more or less details of the waveform on the screen. It is a special feature of the PM3360 that it is possible to select the value in increments of 1 unit rather that with other digital scopes, where sampling rates are selectable in a 1-2-4-8... sequency only.

The highest sample rate (smallest sample time) can be divided continuously with a 16 bit counter. This leads to 65,536 different sample rates.

	PM3361	PM3362	PM3363
smallest sample time (highest sample rate)	100 ns (10 Mio samples/sec)	1 us (1 Mio samples/sec)	20 ns (50 Mio samples/sec)
highest sample time (smallest sample rate)	6,554 ms (~152 samples/sec)	65,54 ms (~15 samples/sec)	1,411 ms (~763 samples/sec)

For the effect of adjusting sampling rate see Fig 4.4.

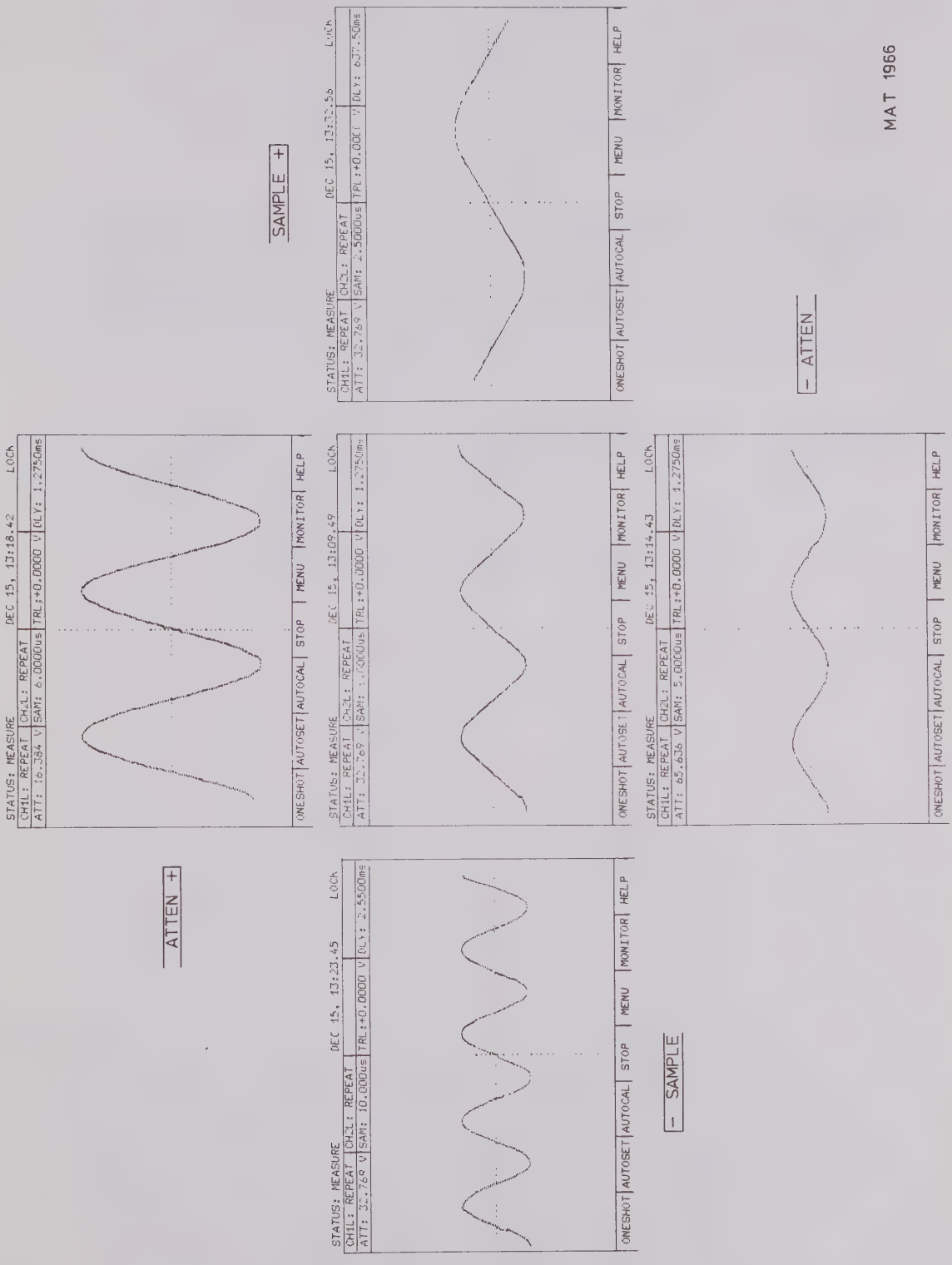
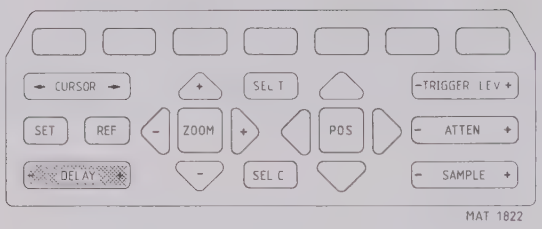


Fig. 4.4 Effect of adjusting attenuation and sample rate

4.2.1.3. Delay (Post- and Pretrigger)



As described in section 2, with PM3360 it is possible to select a pre- or posttrigger operation. Delay is performed with a 16 bit delay counter. Therefore you can record pretrigger information up to the selected recording depth and posttrigger information up to 64k points of sampling time. By pressing DELAY on the - side you will get more pretrigger information, pressing the key on the + side, you will get more postrigger information.

Warning: Delay can be adjusted up to 64k points of time, therefore the vertical trigger line indicator will no longer be visible on screen, if you select a delay larger than the maximum recording depth. The trigger line indicator (fine dotted line on screen) shows the actual time relations (Fig. 4.5).

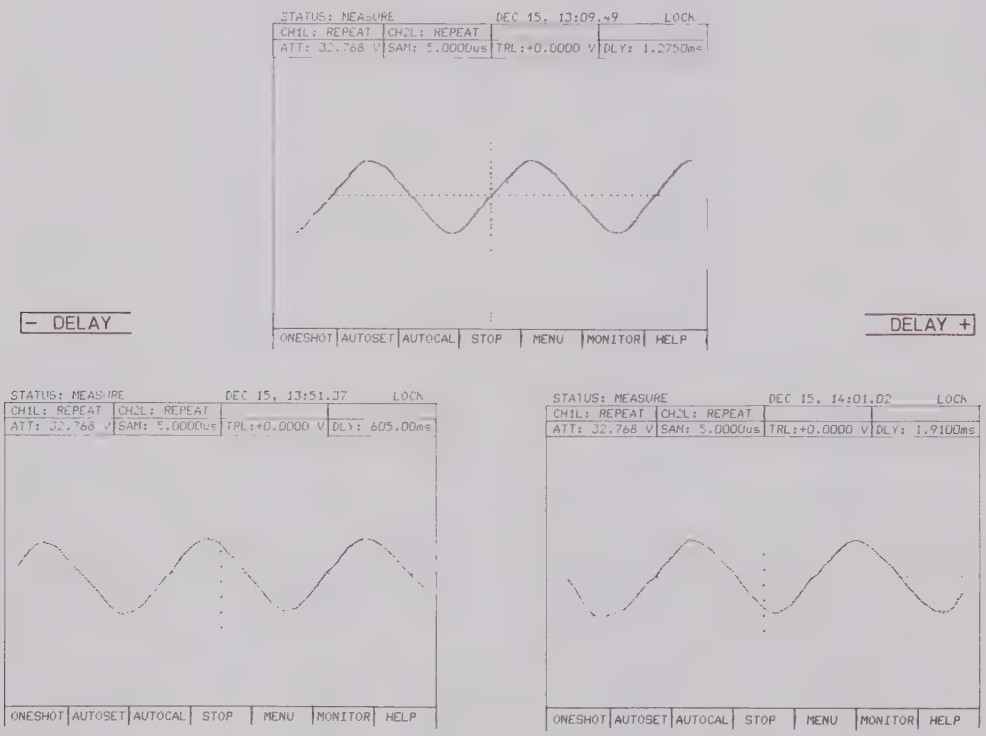
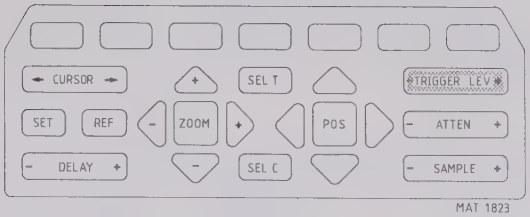


Fig. 4.5 Effect of adjusting delay.

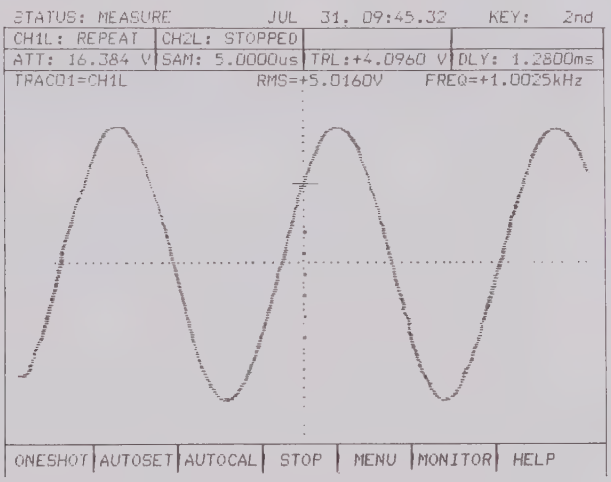
4.2.1.4. Trigger Level



Trigger level can be adjusted on positiv or negative side of zero level (within the selected range). As the PM3360 uses built in digital trigger circuit in each channel, increments or decrements in trigger level values, of course, depend on the resolution of the input channel used. Therefore with an 8-bit converter Trigger level can be incremented or decremented by

$$V = \frac{\text{Full scale}}{256}$$

The selected value can be read on the screen observed as a small horizontal line on the vertical trigger line (Fig. 4.6).



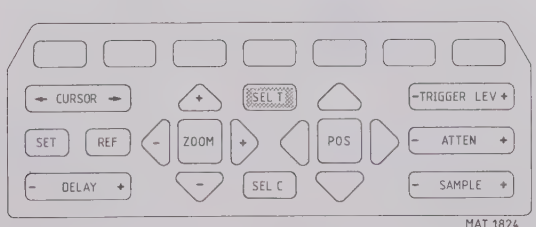
MAT 1968

Fig. 4.6 Trigger line and Trigger level.

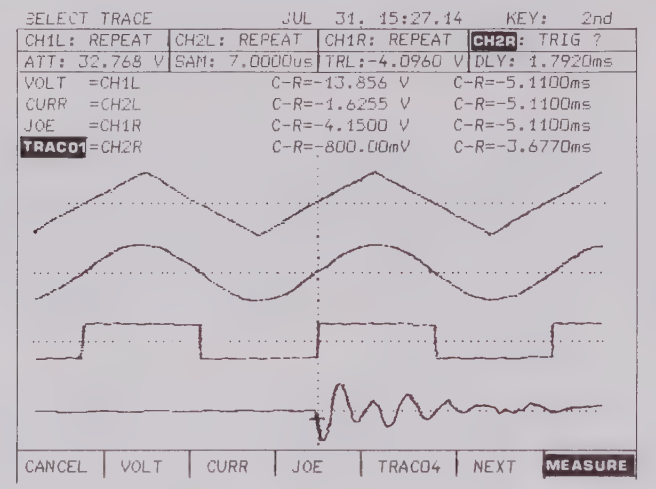
4.2.2. Traces

Traces are by default labeled as TRAC 01, TRAC 02 ... etc., but there is the possibility to assign a certain name to a trace. This can be done in the (General) MENU (see section 4.4.1).

A specific trace is selected by pressing the ´Select Trace´-key (SEL T).



Having done this, the fields above the soft-keys are relabeled with the names of the traces and a specific one can be selected by pressing the corresponding key. The selected trace is indicated by a flashing field (Fig. 4.7).



MAT 1969

Fig. 4.7 Select TRACE.

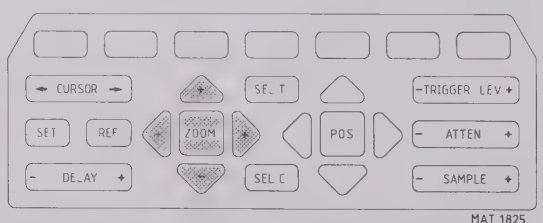
Similar to channels, there is the possibility to deselect all traces by pressing the CANCEL key. In that case changing of parameters referring to any trace is not possible and if one nevertheless tries to do this, a warning will be given.

In DIRECT mode of operation there are dedicated keys for continuous changing of zoom in X and Y direction, default zoom, change of position of a trace in X and Y direction, default position, shifting of cursor and set of reference cursor.

Zooming gives the possibility to compress or expand a trace, positioning to shift a trace in either direction, There are no restrictions with respect to other traces, therefore one can even lay one trace upon the other.

Other operations referring to traces are to select a certain colour or a certain name to a trace, switch a trace on or off, store or erase a trace in reference memory, define the origin of a trace, select interpolation or dotted waveform etc. All these parameters can be changed in SET mode and/or MENU mode.

4.2.2.1. Zoom (Compress or Expand)



A trace can be compressed or expanded over a wide range in either x or y direction. A zoom factor is defined as the number of recorded points in one direction.

The range of zoom factor in x-direction is

$40 \leq$ Number of points on screen $\leq 32\,563$

the range in y-direction is

$27 \leq$ Number of points on screen $\leq 30\,866$

for a 12-bit A/D-converter (PM3362). For 8-bit converters (PM3361, PM3363 these values have to be divided by 16. In x-direction the center of zooming is the cursor, in y-direction the center of zooming is the base line.

By pressing the keys labeled with +, the selected trace can be expanded in x or y direction, by pressing the keys labeled with -, the selected trace can be compressed (see Fig. 4.8).

By pressing the mid key labeled zoom, the zooming factor of the selected trace can be set to a default value. This default value can be programmed in SET mode (see section 4.3.3).

Note: Only PM3360 offers a wide variety of continuously adjustable zooming factors, rather than in 1-2-4-8 ... sequence. In addition, zooming can even be done while a repetitive recording is performed and not only while it is stopped.

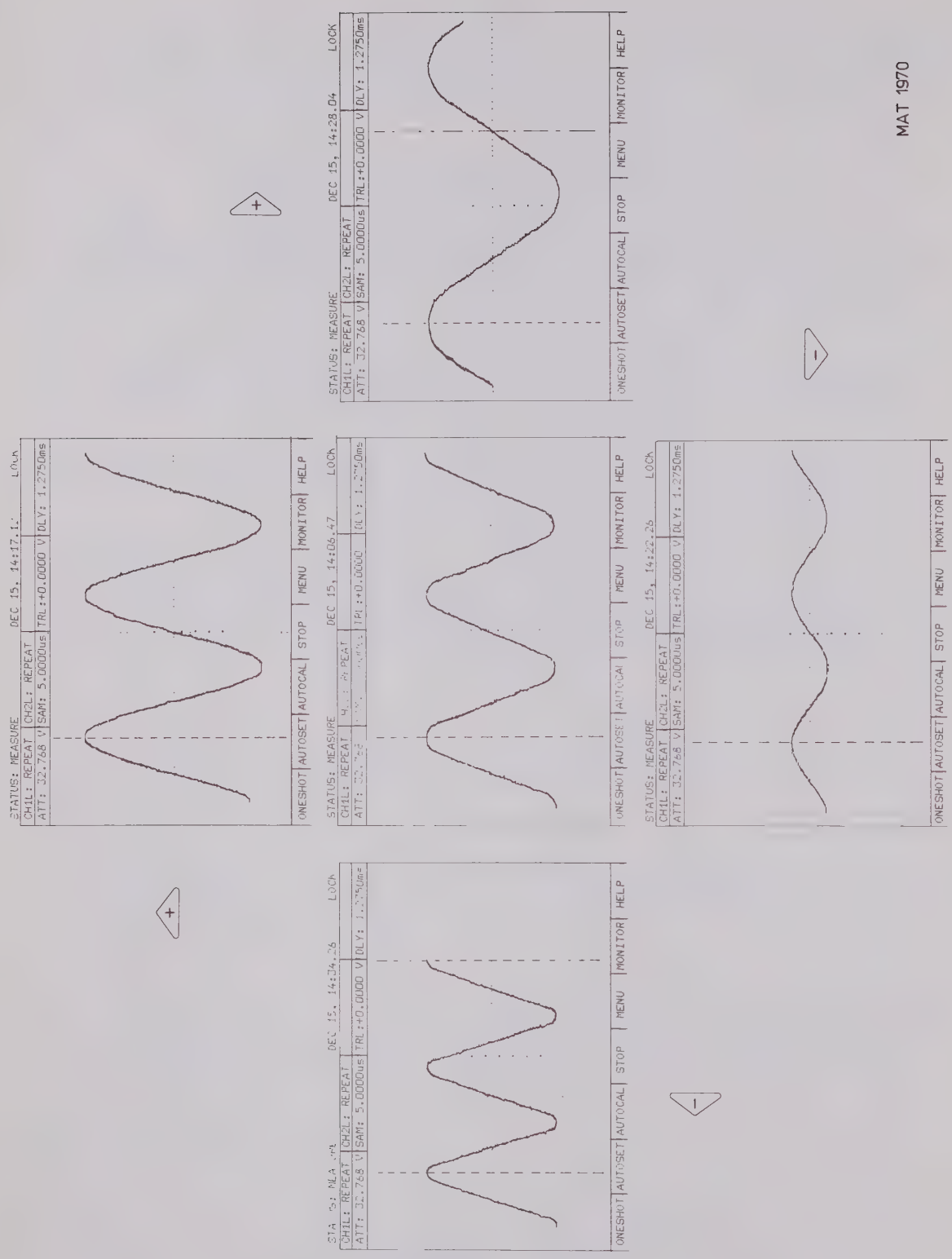
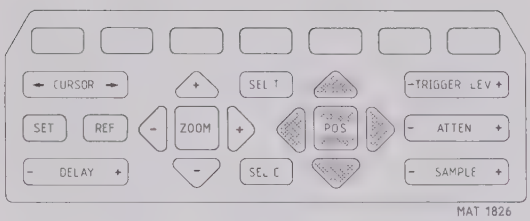


Fig. 4.8 Effect of zooming

MAT 1970

4.2.2.2. Position



By using an PM3360 one has another very useful advantage. There are no restrictions in positioning a trace on the screen. Traces even may overlap. So exact comparisons can take place very easy.

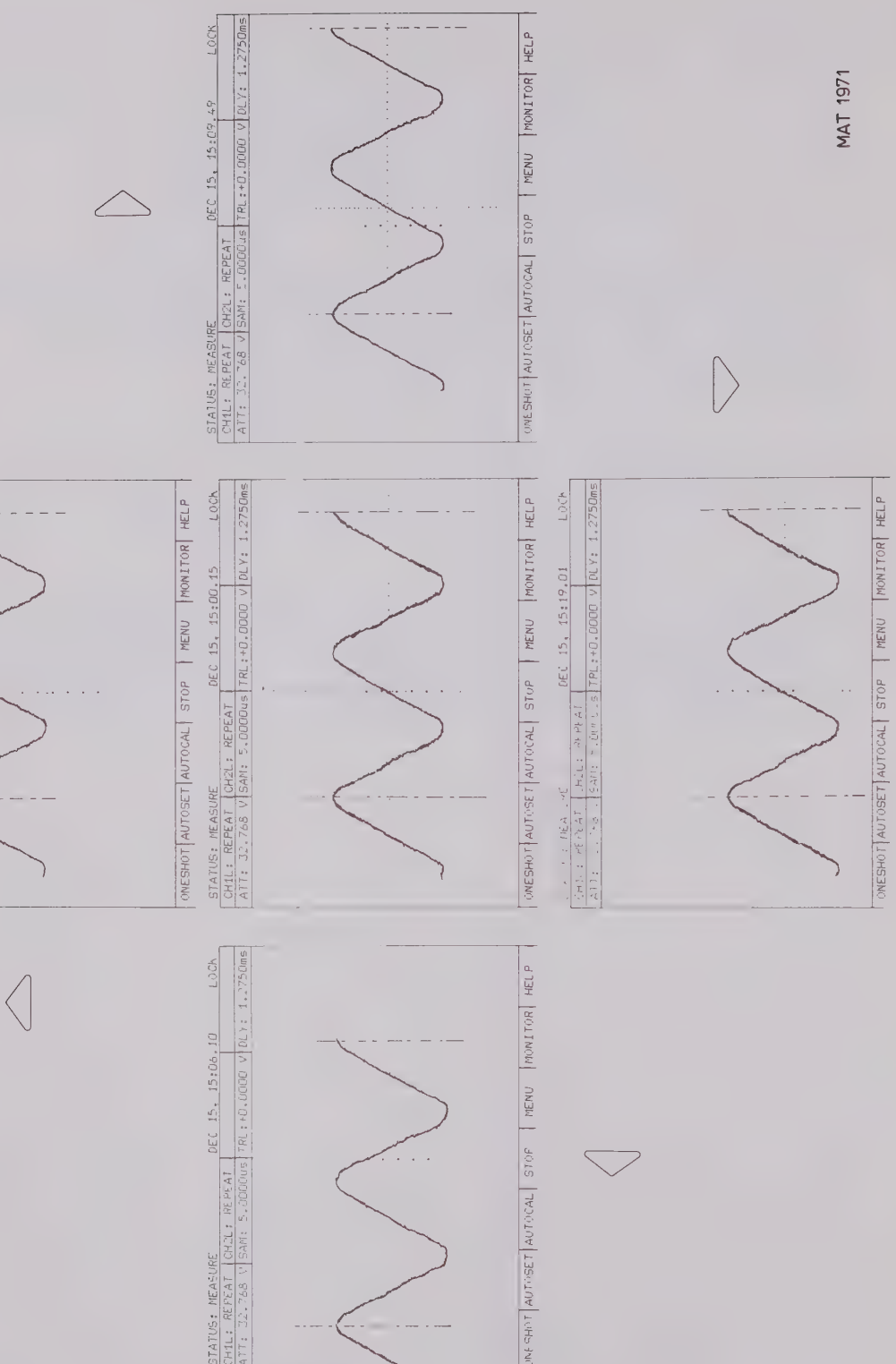
In X-direction the cursor can be shifted from

- 32 592 to + 32 502

and in Y-direction the base line can be shifted from

- 32 647 to + 32 647

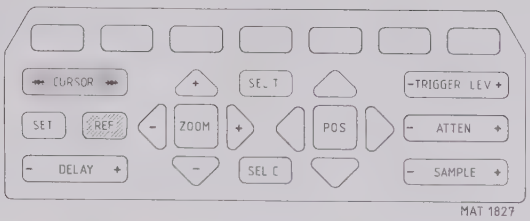
with respect to the coordinate system origin (see section 4.8.6.3). The four triangular keys give the direction of shifting position. Similar to default zooming value, the user has the possibility to program a default positioning in SET mode (see section 4.3.3).



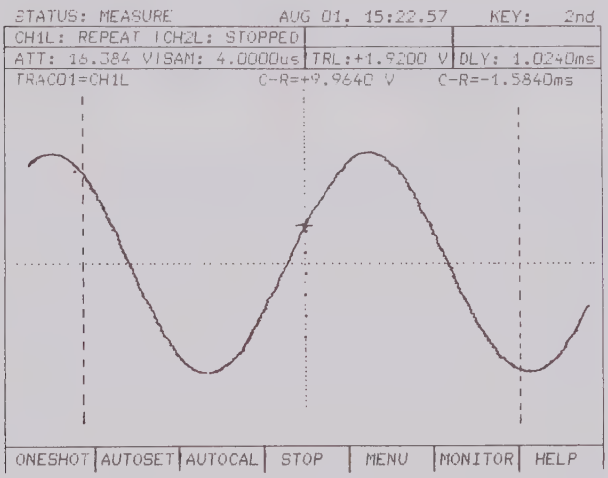
MAT 1971

Fig. 4.9 Effect of positioning

4.2.2.3. Cursor and Reference Cursor



The technique of using a cursor and reference cursor is the basic instrument to perform quantitive measurements on the recorded signal. The cursors as well as the trigger lines are shown as dotted lines on the screen, cursor as a coarse, reference cursor as a medium and trigger line as a fine dotted line (Fig.4.10)



MAT 1972

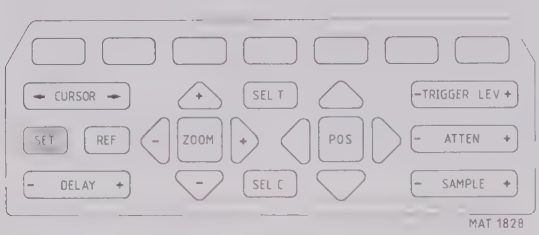
Fig. 4.10 Cursor and reference cursor

By pressing the CURSOR-key on the left or right side the cursor can be shifted left or right. By pressing the REF-key, the reference cursor is set to the actual position of the shiftable cursor.

In the DISPLAY-Menu (see Section 4.4.5) you will find a description of what measurements can be selected. The example in Fig. 4.10 shows a C-R measurement (´cursor minus reference cursor´) in amplitude and time. It gives you the voltage and time difference between the intersection points of cursor, reference cursor and waveform.

4.3. SET MODE

Another special and unique feature of the PM3360 is the possibility to set almost every parameter of the instrument in a fast and simple procedure to a selected condition or value without changing from MEASURE mode to MENU mode. This gives the advantage of an easy to handle setting of some different coarse values for a parameter e.g. trying to find a convenient trigger level. This way of operation is to be done in the following procedure. Pressing SET-key on keyboard #1 leads to a relabeling of the softkeys.



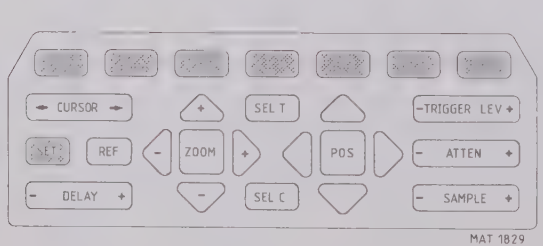
A selection of parameter-names is displayed. Pressing NEXT leads to two more selections. These parameters are called variables (Section 4.3.1). If you now press the softkey for a special parameter all softkeys are relabeled again with the conditions or coarse values valid for this parameter. It is to set by pressing the corresponding softkey.

In addition, there is the possibility to select a coarse value for one of the parameters for which dedicated keys exist like attenuation, sampling rate, trigger level, delay, zoom, position, cursor and reference cursor (Section 4.3.2). The operating procedure is: Pressing SET-key and in addition one of these keys. Then the softkeys will be relabeled with parameter values. Pressing NEXT will again lead to one or more other sets of parameter-values.

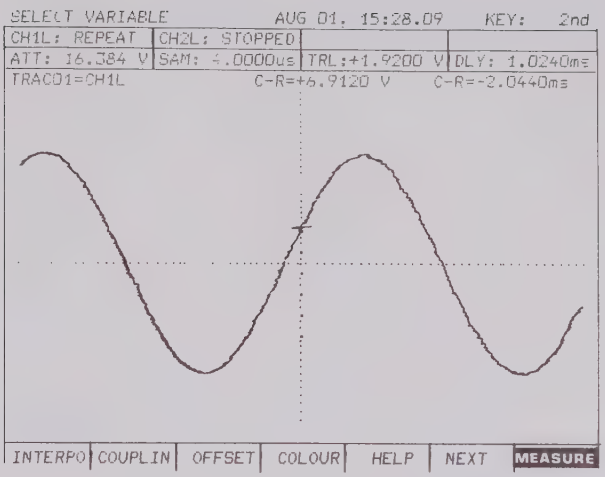
The use of the SET-key and either default zoom (ZOOM) or default position (POS) keys will give the possibility to programme a default value for zoom or position (Section 4.3.3).

Note: You will find out later that the SET-key is also used for various tasks in MENU-mode.

4.3.1. Variables



After having pressed the SET-key, the softkeys are relabeled with the following parameters (Parameters of channels or traces always refer to the selected channel or trace): Interpolation of selected trace (INTERPO), coupling of selected channel (COUPLING), offset of selected channel (OFFSET), color of selected trace (COLOR), frequency of the build in calibrator (CALFREQ), level of the built in calibrator (CALLEVE), coupling of extern trigger in (EXTCOUP), trigger level of extern trigger in (EXTLEVE), enabling or disabling of extern arm in (EXTARM) and attenuation factor of used probes (PROBE). Fig. 4.11 shows the first set of parameters in SELECT VARIABLE status.

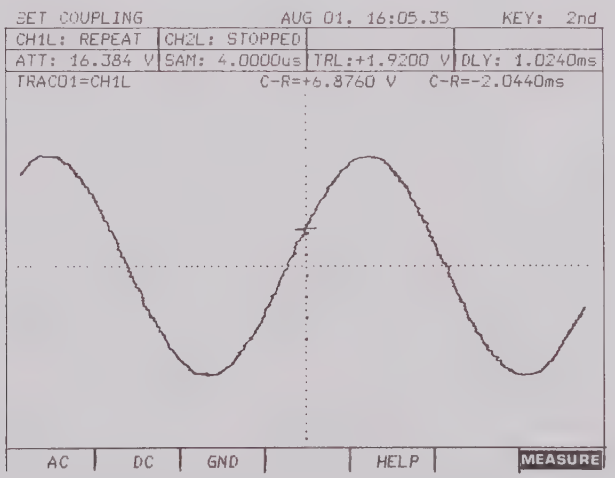


MAT 1973

Fig. 4.11 SELECT VARIABLE

Beside a softkey for HELP and NEXT you will find a softkey labeled MEASURE. It is used to return to MEASURE mode after having performed a SET-operation.

A first example of what conditions are to be found: After having selected COUPLIN, softkeys are relabeled with the conditions AC, DC, GND. The wanted condition is set by pressing the corresponding softkey (Fig. 4.12.)



MAT 1974

Fig. 4.12 SET COUPLING

Another example is to set a certain probe factor. When having selected one in SET PROBE the probe factor is automatically taken into account in every corresponding amplitude value like attenuation, trigger level, etc.. Fig. 4.13 shows this when having selected a 1:10 probe factor. Full scale of 16.384 V has been converted to 163.84 V.

Note: In MENU mode also other probe factors can be selected.

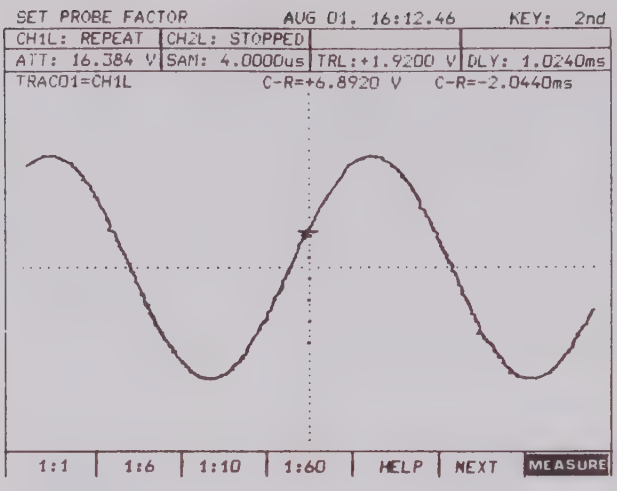


Fig. 4.13 SET PROBE FACTOR

You will also find a label named SAVE. This is used to store a trace in the reference memory. Softkey 1 is then labelled MEMORY, and when pressed the selected trace is stored in memory (also see section 4.4.1.2)

Table I shows the available variables and which conditions or values can be selected in SET mode.

Interpolation of selected trace (INTERPO)	OFF	LINEAR			
Coupling of selected channel (COUPLIN)	AC	DC	GND		
Offset of selected channel (OFFSET)	-1 0	-3/4 +1/4	-1/2 +1/2	-1/4 +3/4	 +1
Colour of selected trace (COLOR)	BLACK RED	GREEN YELLOW	BLUE MAGENTA	CYAN WHITE	
Calibrator frequency (CALFREQ)	0(DC)	1kHz			
Calibrator level (CALLEVE)	0 800mV	100mV 1,6V	200mV 3,2V	400mV 6,4V	
Coupling of extern trigger in (EXTCOUP)	AC	DC			
Trigger level of extern trigger in (EXTLEVE)	-65.563 V 0 V	-49.152 V +16.384 V	-32.768 V +37.768 V	-16.384 V +49.152 V	 +65.024 V
extern arm in (EXTARM)	ENABLE	DISABLE			
extern probe Factor	1:1 1:100	1:5 1:500	1:10 1:1000	1:50 1:5000	

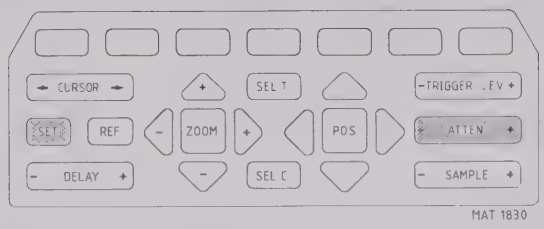
Table I: Available variables and their conditions or values in SET-mode.

4.3.2. Coarse Values

In SET-mode, there is also the possibility to select a coarse value for one of the parameters, for which dedicated keys exist. This is the case for channel parameters like attenuation, sampling rate, trigger level and delay and for trace parameters like X- and Y zoom, Z- and Y position, cursor and reference cursor. In addition, a default value for zoom and position can be programmed.

The operating procedure is pressing the SET-key, which leads to the SELECT VARIABLE state and, in addition, pressing the parameter-DIRECT-key of the parameter one wants to set to a coarse value. The softkeys are then relabeled with coarse values for the selected parameter. You will also find a HELP, a NEXT and a MEASURE label for getting operating support, going over to another set of values and returning to MEASURE mode.

4.3.2.1. Set Attenuation



After pressing SET and ATTEN the softkeys are relabeled and one of the levels can be selected by pressing the relevant softkey.

4.3.2.2. Set Sampling Rate

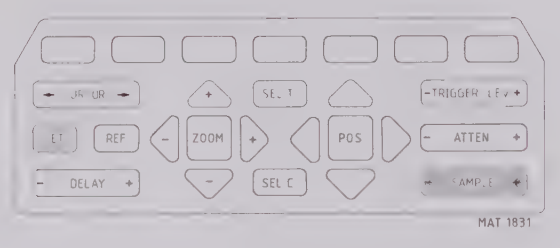


Fig. 4.14 shows an example for having pressed SET and SAMPLE. A selection of sampling time intervalls is displayed to allow the setting of a certain one.

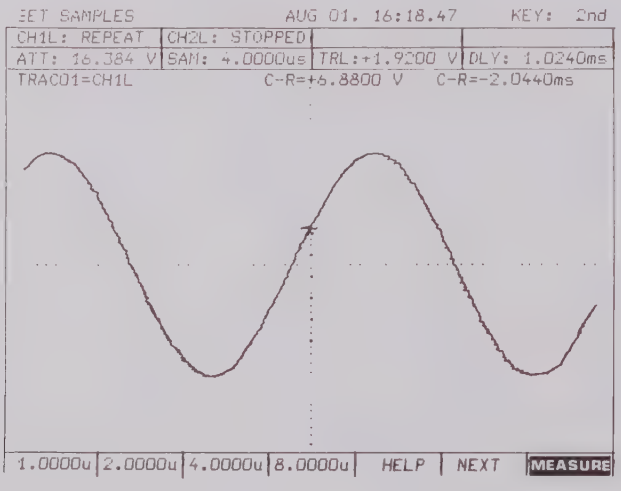
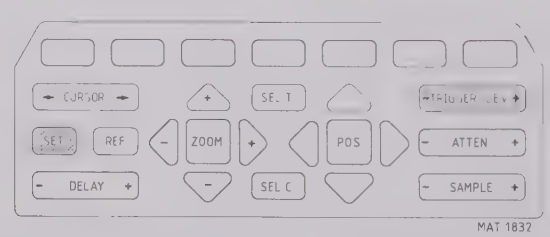
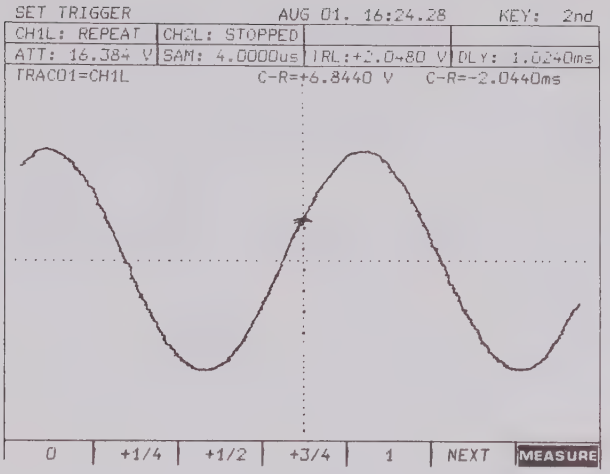


Fig. 4.14 SET SAMPLES

4.3.2.3. Set trigger level



Another example is to be found in Fig. 4.15, setting a trigger level. Trigger level is offerd in form of a fraction of input range. This means that with an attenuation range of 163,84V, as it is shown (note: a probe factor of 1:10 has been programmed), the -1/4 fraction represents a trigger level of -40,96V and the -1/2 fraction represents a trigger level of -81,92V.

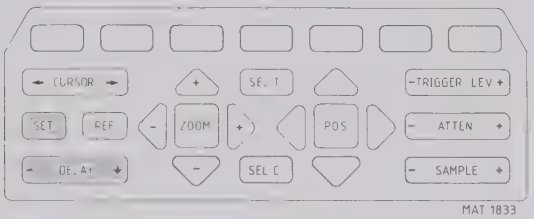


MAT 1977

Fig. 4.15 SET TRIGGER LEVEL

Note: OFFSET values are also given in fractions of the input range in SET mode.

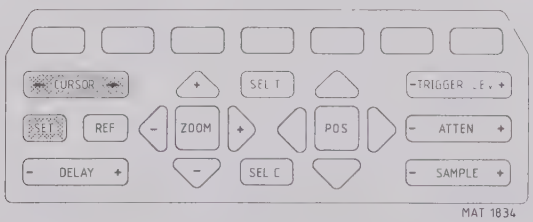
4.3.2.4. Set Delay



MAT 1833

DELAY is given in number of samples rather than in delay time. Therefore is SET mode it is only possible to select a DELAY within the recorded points, that means one can select full pretrigger to full posttrigger in this mode of operation, but no delay bigger than the full time base. This would have to be done in DIRECT mode or MENU-mode. By selecting a delay, the trigger line will move accross the screen.

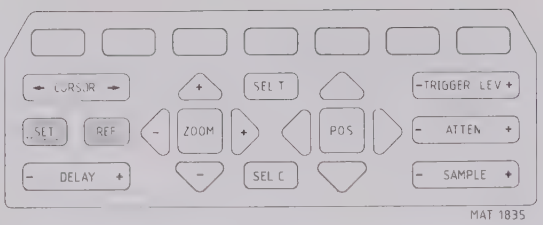
4.3.2.5. Set Cursor



MAT 1834

The cursor can be set to predefined positions on the screen. These positions are the left and the right side of the screen and all positions with an interval of 1/8 of the screen width in between. The default position at power up is the left side.

4.3.2.6. Set Reference Cursor



The reference cursor is set in the same way as the cursor. The default at power on is the right side of the screen.

4.3.2.7. Set Zoom

By pressing SET and + or - (above and below ZOOM) the zoom factor of the vertical direction can be selected by the softkeys. By pressing SET and + or - (left and right of ZOOM) the horizontal zoom factor can be selected. The zoom factor is selected as a number of dots on the screen.

4.3.2.8. Set position

Set position is done in the same way as set zoom.

4.3.2.9. Survey of course values

Table II shows the parameters for which dedicated keys exist and which values can be selected in SET mode.

Input range, attenuation (ATTEN)	131,07V 8,1920V 256mV	65,536V 4,096V 128mV	32,768V 2,048V	16,384V 1,024V	512mV
Sampling time (SAMPLE)	100ns 1,6us 51,2us 1,638ms	200ns 3,2us 102,4us 3,2768ms	400ns 6,4us 204,8us 6,5536ms	800ns 12,9us 409,6us	25,6us 819,2us
Trigger level fraction of input range (TRIGGER LEV)	-1 0	-3/4 +1/4	-1/2 +1/2	-1/4 +3/4	 +1
Number of samples after trigger (DELAY) *	0 256	64 320	128 384	192 448	 511
Position of cursor (CURSOR) *	0 256	64 320	128 384	192 448	 511
Position of reference cursor (REF) *	0 256	64 320	128 384	192 448	 511
X-zoom (number of points on screen)	40 640	80 1280	160 2560	320 5120	 10240
Y-zoom (number of points on screen)	100 1903	200 3824	400 7716	800 15433	 30866
X-position (with reference to cursor)	-1 0	-3/4 +1/4	-1/2 +1/2	-1/4 +3/4	 1
Y-position (with reference to base line)	-1 0	-3/4 +1/4	-1/2 +1/2	-1/4 +3/4	 1

Table II Coarse values

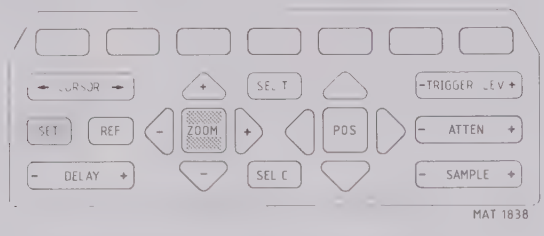
* Example shown with a selected recording depth of 512 points

4.3.3. Default zoom, Default position

As mentioned before, it is another special feature of the PM3360 system to be able to program a certain default zoom value and position of the traces. This can be done in SET mode.

The values you have programmed for default zoom and default position refer to each trace and not only to the selected one. Newly programmed default values are accepted by pressing the corresponding key in MEASURE mode.

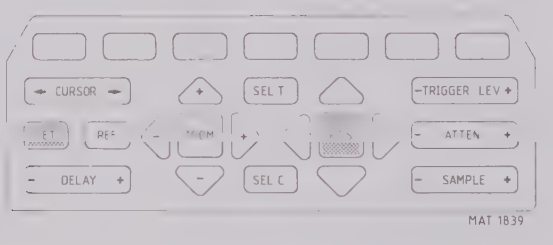
4.3.3.1. Set zoom default



By pressing SET-key and the default zoom key (ZOOM), softkeys are relabeled with a set of default conditions for zoom.

The following conditions can be programmed:
1:1 means that one recordable data point (LSB) is assigned to one point on screen. Fullscreen (FULLSCR) means that the number of recorded points is zoomed to the full space in X-direction (320 points) and the amplitude is zoomed to the free space in Y-direction. Halfscreen (HALFSCR) and quarterscreen (QUARTSCR) is the same situation in X-direction, but amplitude is zoomed to half of free space on screen or quarter of free space on screen respectively. Pressing NEXT leads to the label ACTUAL which gives the user the possibility to programme any zoom in X- and Y-direction, that has been selected with the DIRECT-keys or in MENU mode and is valid at this time.

4.3.3.2. Set position default



Similar to default zoom is the procedure of programming conditions of a default position.

Pressing SET-key and the default position key (POS), softkeys are relabeled with the following programming conditions.

TRACE means, that the whole trace is centered on screen.
Cursor (CURSOR), reference cursor (REFEREN) or trigger line (TRIGGER) can be selected as center of the trace by pressing the corresponding softkey. The Y-position of the baseline is calculated with respect of the free space on screen. This means if there is a lot of information (trace-channel assigment and displayed values) visible on screen the baseline will be centered to the free space automatically. Pressing NEXT leads to the label ACTUAL, which gives the user the possibility to programme any position in X- and Y direction, that has been selected by using DIRECT-keys or in MENU-mode.

4.4. MENU MODE

To have a comprehensive survey of all parameters of the instrument, DIRECT mode and SET mode are supplemented by the usual and wellknown MENU mode. When the instrument is switched on, it is working in MEASURE mode.

By pressing the softkey labeled MENU the display is switched to the (GENERAL) MENU and softkeys are relabeled with the names of the other menues. Pressing the corresponding softkey leads to either

Input MENU(INPUTS) where all the input channels parameters are to be found.
Trace MENU (TRACE) where all the trace parameters are to be found.
Trigger MENU (TRIGGER) where trigger conditions and extern trigger in and extern arm in parameters are handled.
Display MENU (DISPLAY) for selecting various measurements ect. on traces.

4.4.1. (GENERAL) MENU

The (GENERAL) MENU allows to coordinate the instrument´s base organization.

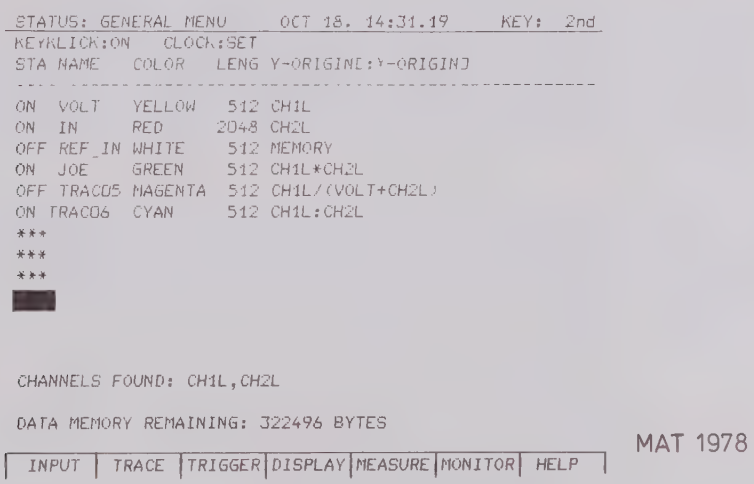

STATUS: GENERAL MENU OCT 18. 14:31.19 KEY: 2nd
KEYKLICK:ON CLOCK:SET
STA NAME COLOR LENG Y-ORIGIN[:X-ORIGIN]
ON VOLT YELLOW 512 CH1L
ON IN RED 2048 CH2L
OFF REF_IN WHITE 512 MEMORY
ON JOE GREEN 512 CH1L*CH2L
OFF TRACE5 MAGENTA 512 CH1L/(VOLT+CH2L)
ON TRACE6 CYAN 512 CH1L:CH2L
***
***
***
CHANNELS FOUND: CH1L,CH2L
DATA MEMORY REMAINING: 322496 BYTES
MAT 1978
INPUT TRACE TRIGGER DISPLAY MEASURE MONITOR HELP

Fig. 4.16 (GENERAL) MENU

The following items are displayed and can be manipulated there: the status of a TRACE (STA), the name of a trace (NAME), the color of a trace (COLOR), the recording length of an input channel (LENG) and the origin of data for Y- and X-direction respectively (Y-ORIGIN[:X-ORIGIN]).

This is supplemented by the following facilities, the KEYKLICK field, which allows with the ON and OFF to switch the keyklick feature, the CLOCK:SET field for setting the Real Time Clock (see section 4.4.1.1) and a display what channels had been found and remaining data memory size. A red cursor will be displayed on the screen and is to be positioned to that parameter which is to be manipulated (by using the position keys, up, down, left, right). The default position key (POS) has no effect.

As soon as the cursor is positioned on the proper parameter press SET-key. The locator field starts blinking, indicating that input of condition or value can be performed. At the same time the softkeys will be relabeled with the appropriate conditions, values, etc. Input performed by pressing the corresponding softkey. The display shows the new state of the parameter and softkeys are relabeled with the names of the menues

Here is a more detailed description of the parameter manipulation possibilities:

4.4.1.1. General facilities

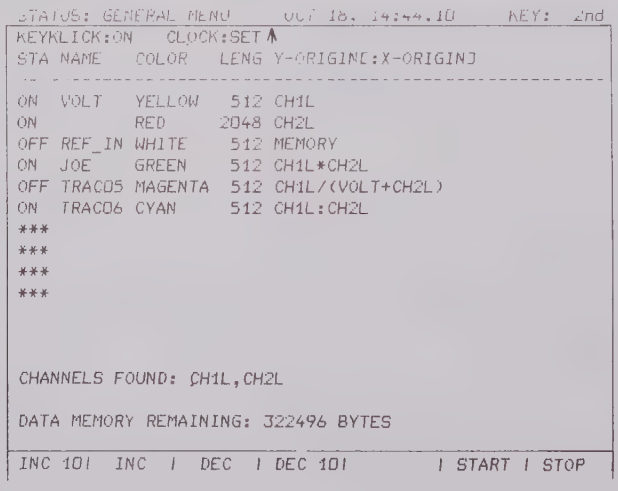
Keyklick (KEYKLICK):
can be switched on or off by pressing SET-key and the corresponding softkey.

Real time clock setting (CLOCK:SET):

Month, day and time in hours minutes and seconds are displayed on the screen on the right side of the status indicator (see Fig. 4.17).

To set the clock use the following procedure:

- select (GENERAL) MENU
- move red cursor field to CLOCK:SET by using position keys
- press SET-key
  cursor fiels starts blinking - soft keys are relabeled
- move white arrow left or right by using corresponding position key to the time parameter (month, day, hour, minute, second) you want to set.
- parameter can be incremented or decremented by 1 or 10 by pressing the labeled softkey
- clock can be stopped or restarted by pressing labeled softkey
- delimit clock-set-procedure by pressing SET-key again (restart of clock is performed automatically)


STATUS: GENERAL MENU OCT 18, 14:44.10 KEY: 2nd
KEYKLICK:ON CLOCK:SET
STA NAME COLOR LENG Y-ORIGINC:X-ORIGINJ
ON VOLT YELLOW 512 CH1L
ON RED 2048 CH2L
OFF REF_IN WHITE 512 MEMORY
ON JOE GREEN 512 CH1L*CH2L
OFF TRACO5 MAGENTA 512 CH1L/(VOLT+CH2L)
ON TRACO6 CYAN 512 CH1L:CH2L
***
***
***
***
CHANNELS FOUND: CH1L,CH2L
DATA MEMORY REMAINING: 322496 BYTES
INC 101 INC I DEC I DEC 101 I START I STOP

MAT 2007

Fig. 4.17 Set of Real Time Clock

4.4.1.2. Trace status (STA)

In this field you can switch a trace on or off and store or erase a trace (in reference memory) pressing SET-key and the corresponding softkey (Fig. 4.18).

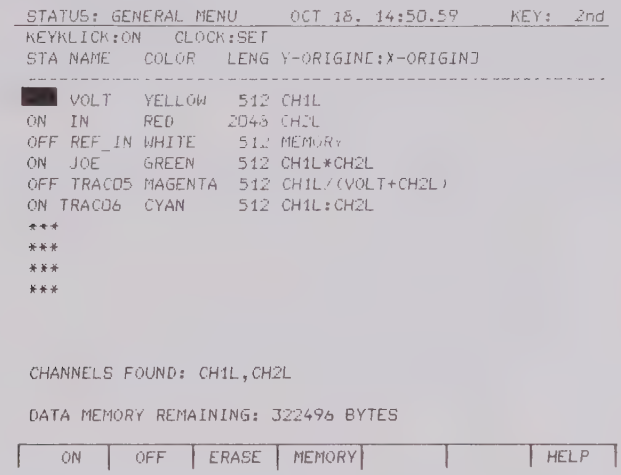


Fig. 4.18 Trace STATUS manipulation

Up to ten traces can be established by the user. By switching on the instrument one trace is generated for each existing channel by default. If you want to generate a new trace, pass over to a status field showing *** and press ON or OFF. If one switches OFF the trace still exists but is not displayed on screen.

Pressing ERASE leads to a complete erasing of the trace in reference memory and this line in the (GENERAL) MENU vanishes. If you press MEMORY the trace is stored (freezed) in reference memory. This is indicated in the corresponding origin field as it can be seen in Fig. 4.18 with trace REF-IN.

4.4.1.3. Name of a trace (NAME)

It is up to the user to give a freely selectable name to a certain trace which is a very useful feature for documentation. To do this, select a certain NAME with the cursor. After having pressed SET-key, the softkeys are relabeled with a set of standard names and an EDIT sign (Fig. 4.19). For input of non standard name the softkey EDIT has to be pressed. The softkeys are relabeled with some editing functions and now the name can be typed in or can be changed. (Also refer to section 4.4.1.7).

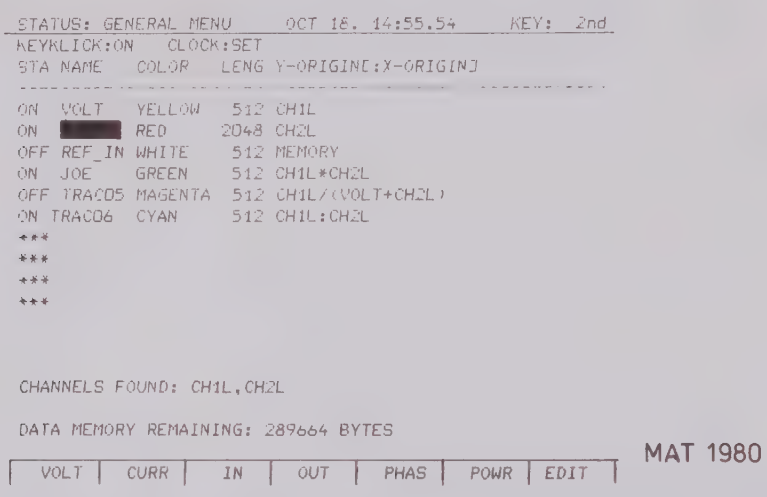


Fig. 4.19 Trace NAME manipulation

4.4.1.4. Color of a trace (COLOR):

To ´paint` a trace, select the corresponding COLOUR-field with the cursor. By pressing SET-key, you will get a choice of colours at softkeys. The following colours are available:
black, blue, green, cyan, red, yellow, magenta, white.

4.4.1.5. Recording length of input channel (LENG):

It´s up to the user to select the recording length free, up to a maximum of 4k per channel.
After having set the cursor on the corresponding field and having pressed the SET-key, the softkeys are relabeled with a set of prepared recording lengths which can be selected. Using the EDIT key offers the possibility to select any recording length of up to 4k by using keyboard #2.

Note: One should be aware of the position of cursor, reference cursor or trigger line because if you select a smaller recording length as has been used before, it could happen that one of these lines is out of picture.

4.4.1.6. Origin of data for a trace (ORIGIN):

A certain origin of a trace can be selected by positioning the cursor to the corresponding ORIGIN-field and pressing the SET-key. The softkeys are relabeled with the names of the input channels available and then can be selected by pressing the corresponding softkey.

Input can also be done by using the EDIT capabilities. This is to be used for input of origins for calculated traces e.g. CH1L*CH2L or origin for X/Y-Mode like e.g. CH1L:CH2L.

If the origin defined contains only one operand, a Y/t-mode has been defined, if there are two operands separated by a colon an X/Y-mode has been defined.

4.4.1.7. Edit parameters:

For manipulation of some of the parameters you will find an EDIT facility. If you press EDIT, softkeys will be relabeled as shown in Fig. 4.20.

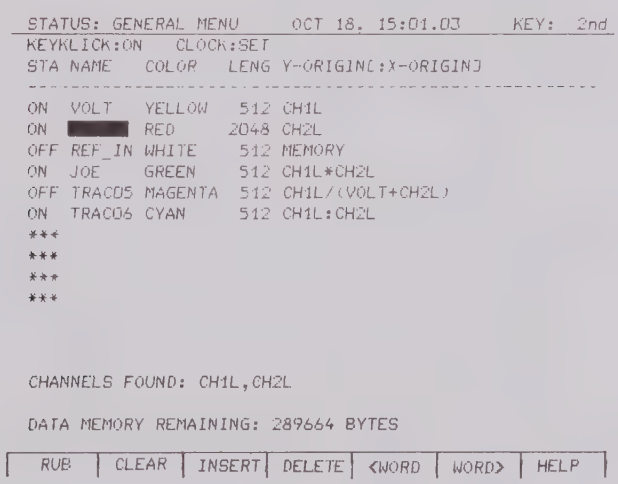


Fig. 4.20 EDIT procedure

At the same time a character cursor will appear. This cursor can be shifted left or right by using the corresponding position keys and can be placed on the first character of the word, at the left side (<WORD) or at the right side (WORD>) of the Cursor by pressing the corresponding softkey.

Pressing the softkey DEL deletes the character at the cursor position. Pressing RUB results in deleting the character at cursor position and moving the cursor 1 position to the left.
An INSERT flag can be switched on or off by pressing the corresponding key. In this case new characters can be filled in between existing characters. For input of characters use keyboard #2. The input is delimited by pressing carriage return (CR) or SET-key once again.

4.4.2. INPUT MENU

Out of MENU mode the Input MENU is activated by pressing the softkey named INPUT. The INPUT menu serves for display and manipulation of all the parameters depending on channels. (Fig. 4.21.).
In the INPUT menu, before the SET key is pressed the softkey are relabeled with the name of the other menu´s (Fig. 4.21).

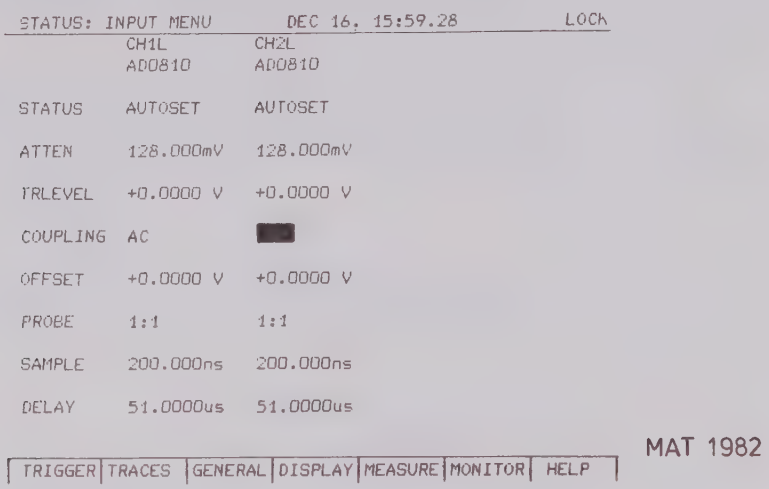


Fig. 4.21 INPUT MENU

The following items are available: The recording status (STATUS), the input attenuation (ATTEN), the trigger levels (TRLEVEL), coupling-mode of input channels (COUPLING), offset of input voltages (OFFSET), attenuation factor of external probe (PROBE), sample time (SAMPLE) and recording delay (DELAY). In addition above each column, there is displayed what channels are existing and what types of input modules are plugged in (fig. 4.22).
These items can be changed by positioning the red cursor field on the parameter one wants to change by use of the position keys. When the SET-key is pressed, the cursor starts blinking
and the changes can be made by using the relabeled softkeys or the edit function.

4.4.2.1 Recording status (STATUS)

Put the cursor field on the parameter one wants to change, under the channel number in which the change has to be made. After pressing the SET-key the softkeys are relabeled with: ONE SHOT, REPEAT, AUTOTRG, AUTOSET, AUTOCAL and LINK (see Fig. 4.22a).
When the softkey, labeled with LINK is pressed, all channels will get the same status as the channel in which the cursor field was at the moment the SET-key was pressed. The functions of the other softkeys are already explained in section 4.2.1.

4.4.2.2 Input attenuation (ATTEN)

The ATTEN line shows the internal full scale ranges multiplied by the corresponding probe factors (attenuation factor of the probe).
The softkey will be relabeled as shown in fig. 4.22b (bottom line).
When using the LINK softkey, all the channels will be set to the attenuation factor selected in the cursor field.

Selecting of a value (e.g. on a PM3361 channel) which is smaller than the smallest possible value of one of the other channels (e.g. PM3362 channel) will result in the smalles value of this last channel (e.g. 512mV instead of the selected 128mV).

Note: When all channel attenuators are linked and the value is decremented, with ATTEN+ key or in INPUT-MENU to a value below 512mV the attenuators of a PM3362 will go into there highest values (65 V or 131 V).

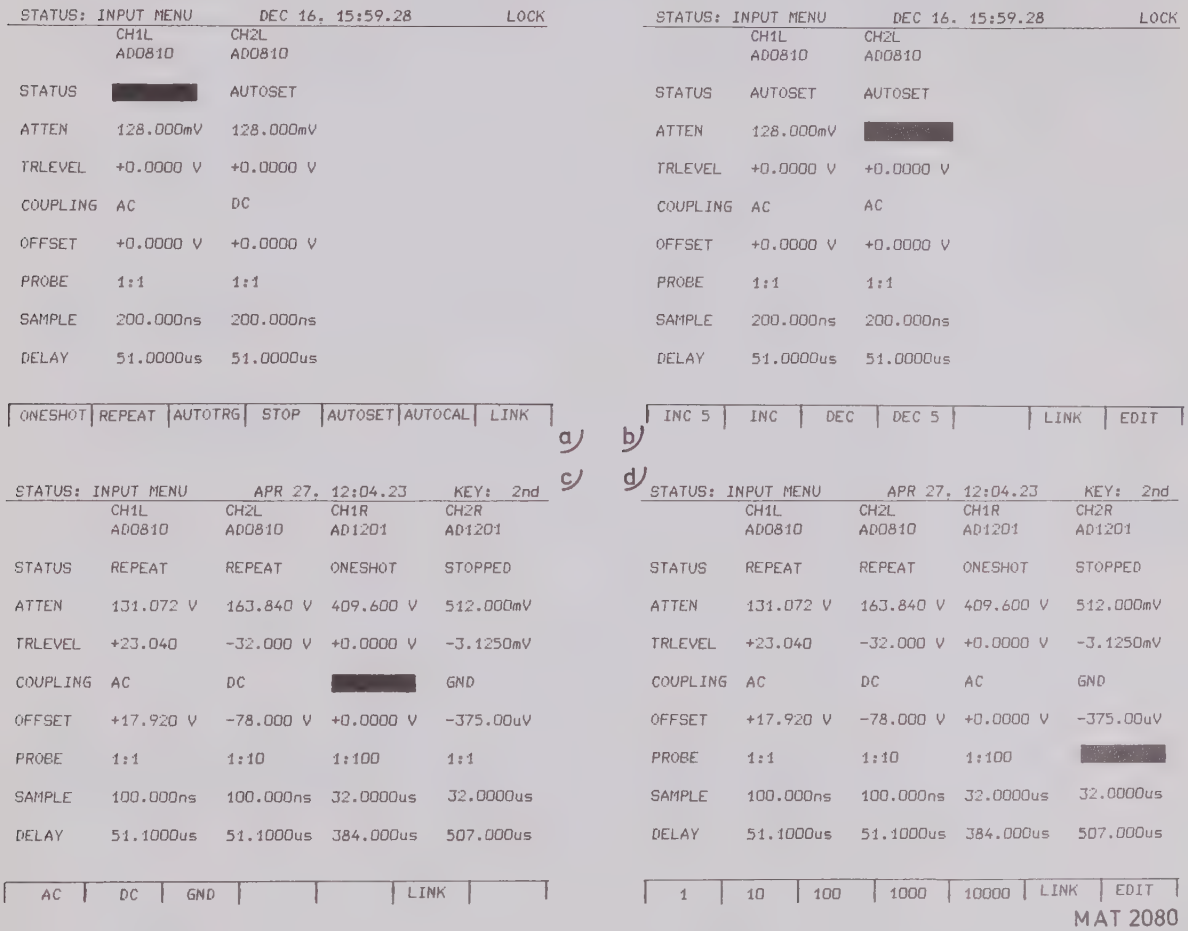

STATUS: INPUT MENU DEC 16, 15:59.28 LOCK
CH1L AD0810
CH2L AD0810
STATUS AUTOSET
ATTEN 128.000mV 128.000mV
TRLEVEL +0.0000 V +0.0000 V
COUPLING AC DC
OFFSET +0.0000 V +0.0000 V
PROBE 1:1 1:1
SAMPLE 200.000ns 200.000ns
DELAY 51.0000us 51.0000us
ONESHOT REPEAT AUTOTRG STOP AUTOSET AUTOCAL LINK
a)
STATUS: INPUT MENU DEC 16, 15:59.28 LOCK
CH1L AD0810
CH2L AD0810
STATUS AUTOSET AUTOSET
ATTEN 128.000mV
TRLEVEL +0.0000 V +0.0000 V
COUPLING AC AC
OFFSET +0.0000 V +0.0000 V
PROBE 1:1 1:1
SAMPLE 200.000ns 200.000ns
DELAY 51.0000us 51.0000us
INC 5 INC DEC DEC 5 LINK EDIT
b)
STATUS: INPUT MENU APR 27, 12:04.23 KEY: 2nd
CH1L AD0810
CH2L AD0810
CH1R AD1201
CH2R AD1201
STATUS REPEAT REPEAT ONESHOT STOPPED
ATTEN 131.072 V 163.840 V 409.600 V 512.000mV
TRLEVEL +23.040 -32.000 V +0.0000 V -3.1250mV
COUPLING AC DC GND
OFFSET +17.920 V -78.000 V +0.0000 V -375.00uV
PROBE 1:1 1:10 1:100 1:1
SAMPLE 100.000ns 100.000ns 32.0000us 32.0000us
DELAY 51.1000us 51.1000us 384.000us 507.000us
AC DC GND LINK
c)
STATUS: INPUT MENU APR 27, 12:04.23 KEY: 2nd
CH1L AD0810
CH2L AD0810
CH1R AD1201
CH2R AD1201
STATUS REPEAT REPEAT ONESHOT STOPPED
ATTEN 131.072 V 163.840 V 409.600 V 512.000mV
TRLEVEL +23.040 -32.000 V +0.0000 V -3.1250mV
COUPLING AC DC AC GND
OFFSET +17.920 V -78.000 V +0.0000 V -375.00uV
PROBE 1:1 1:10 1:100
SAMPLE 100.000ns 100.000ns 32.0000us 32.0000us
DELAY 51.1000us 51.1000us 384.000us 507.000us
1 10 100 1000 10000 LINK EDIT
d)
MAT 2080

Fig. 4.22 Input menu parameter value adjust.

4.4.2.3 Trigger levels (TRLEVEL)

The trigger level can be selected for each channel seperately, or can be linked. When the channels are linked, the relation of the trigger levels is the same as the relation of the attenuation levels. They can be changed by using the set and the softkeys (relabeled as in fig. 4.22b bottom line).
The trigger level value can not be larger than half the attenuation value.

4.4.2.4 Coupling mode (COUPLING)

Coupling of an input channel can be selected by using the set and softkeys. All channels can be linked or set seperately as shown in fig. 4.22c.

AC - only the AC component of the input signal is displayed and used for calculations.
DC - complete input signal is displayed and used for calculations.
GND- the input of the channel is connected to ground.

4.4.2.5 Offset voltage (OFFSET)

The offset voltage is changed in the same way as the trigger level and has the same limitations.

4.4.2.6 Attenuation factor (PROBE)

The attenuation factor (probe factor) can be used to eliminate the probe attenuation.

Note: This is not the same factor as the Amplitude factor in the display menu.

4.4.2.7 Sample time (SAMPLE)

When the sample time is linked the unit can be used as a normal two or four channel oscilloscope. Changing the sample time is done the same way as the attenuator value.

Note: If different types of input modules are used you must be aware that the parameter values are linked step by step. (e.g. PM3361 set to 200n sec. is linked to 2u sec. on a PM3362).

4.4.2.8 Recording delay (DELAY)

The delay parameter is set equal to sample time. It is always bigger than two times the sample time.

4.4.3. TRACE MENU

From MENU mode the TRACE Menu is called by pressing the softkey named TRACE. Trace Menu serves for display and manipulation of all trace parameters comparable to INPUT Menu (Fig. 4.23).

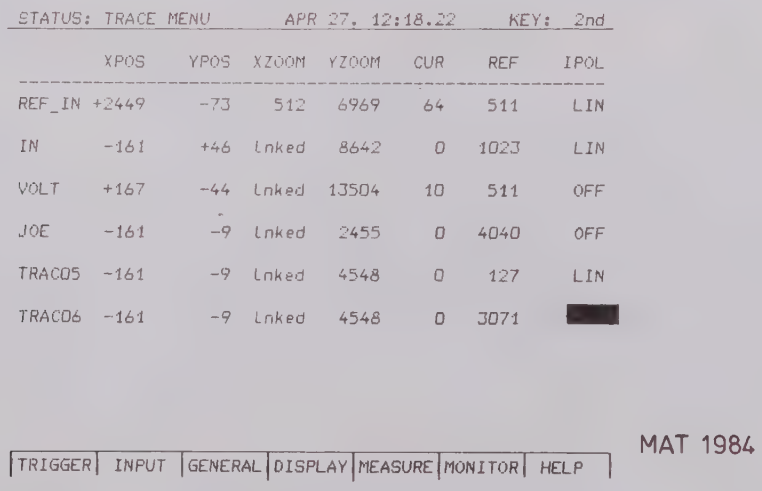

STATUS: TRACE MENU
APR 27, 12:18.22
KEY: 2nd
XPOS YPOS XZOOM YZOOM CUR REF IPOL
REF_IN +2449 -73 512 6969 64 511 LIN
IN -161 +46 Lnked 8642 0 1023 LIN
VOLT +167 -44 Lnked 13504 10 511 OFF
JOE -161 -9 Lnked 2455 0 4040 OFF
TRACO5 -161 -9 Lnked 4548 0 127 LIN
TRACO6 -161 -9 Lnked 4548 0 3071
MAT 1984
TRIGGER INPUT GENERAL DISPLAY MEASURE MONITOR HELP

Fig. 4.23 TRACE MENU

In this menu you will find a list of the existing traces described by their actual names. One has acces to the following items:

X-position of the cursor of a trace (X-POS),
Y-position of the base line of a trace (Y-POS),
number of recorded points displayed in X-direction (X-ZOOM),
number of recorded points displayed in Y-direction (Y-ZOOM),
location of cursor (CURSOR), reference cursor (REF) and interpolation (IPO). Remember, that the position depends on a coordinate system with origin in the middle of free screen, zooming factor in Y-direction is for a 12-bit converter and has to be divided by 16 for 8-bit converters. Position of cursor and reference cursor is the actual position within recorded data points which limits are 0 or 4k, using the maximum recording length.

Note: TRAC05 and TRAC06 have the same position and zooming values. Therefore recorded waveforms are completely overlapped (when using the same input channel). Only reference cursor position is different. Trace parameters can be linked and unlinked in the same way as channel parameters. You can see this at X-Zoom which has been linked together for all traces.

4.4.4. TRIGGER MENU

The TRIGGER MENU offers the possibility to set trigger conditions for theinput channels and the external trigger out to define soft trigger and set the extern trigger in parameters as well as the extern arming in.

Manipulation procedure is the same as with other menues. The red cursor is to be positioned to the parameter field on wants to change by use of the corresponding softkey. After having pressed the SET-key, the cursor field starts blinking and softkeys are relabeled with conditions or values for input.
Fig. 4.24 shows parameter input for trigger condition.

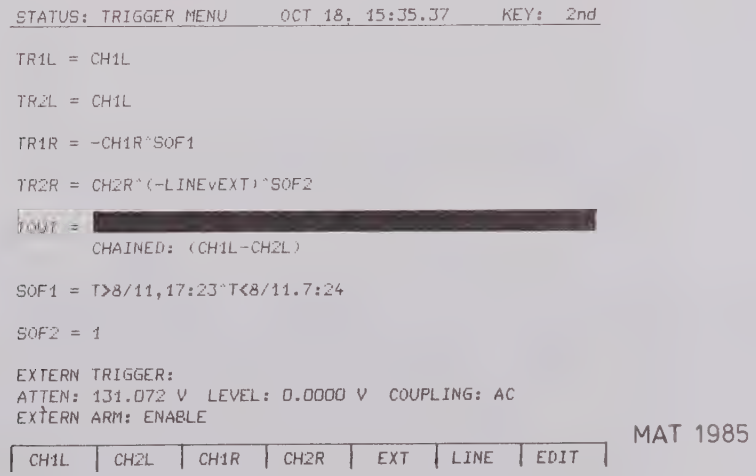


Fig. 4.24 TRIGGER MENU (Trigger condition setting)

TR1L, TR2L, TR1R, TR2R, TOUT are the variables describing the trigger signal for four input channels and the trigger out respectively.

The simplest way is shown with TR1L. Channel CH1L is to be triggered with the rising slope of the trigger signal coming out of CH1L. In addition, the trigger signal out of CH1L is used for triggering CH2L. This is the usual way of trigger operation as with a normal two-channel analog scope.
CH1R is to be triggered by the falling slope of the signal recorded by CH1R if SOF1 is logical 1.

CH2R has got a more complex trigger condition. This channel is triggered if the signal recorded by CH2R is higher than the selected trigger level AND if line trigger signal (LINE) is lower than zero or extern trigger signal (EXT) is higher than extern trigger level that has been adjusted AND if SOF2 is logical 1.

If one has placed the red cursor on the corresponding trigger condition field (shown here for trigger out (TOUT) and has pressed SET-key one gets a relabeling of the softkeys with the names of the available trigger sources. This is up to four input channels (CH1L, CH2L, CH1R, CH2R) depending on how many exist in the system (all four possible in this example), the extern trigger in (EXT) and the built in line trigger (LINE).

The softtrigger SOF1 or SOF2 must be defined as an equation to a logic function. This logic function can be given as a permanent ´0´ or ´1´ or as one or more time ranges separated by logic ´OR´ (symbolized by V).
This time range can be:
up till a specific moment (T<)
from a specific moment onwards (T>)
or in between two moments (T> ´AND´ T<)

Example: SOF1 = T<5/15, 11:35 V T> 5/15, 12:35

The specified moments are called Time string and consist of:
Month/day,hour:minute.second;10th of seconds
from which, starting from the right, any part can be deleted.

Example: SOF1 = T<5/15, 11:35.20;8
this means: at May 15, 11.35 h. and 20.8 seconds soft trigger is terminated.

Example: SOF1 = T>5/15, 11:35 ∧ T<5/15, 12
this means: at May 15 between 11.35 h. and 12 o´clock, the soft trigger is valid.
(∧ is the symbol for logic AND)

In figure 4.24 softtrigger SOF1 has been defined to be logical 1 in a given time frame. The selected expression leads to Softtrigger SOF1 being logical 1 for 1 minute and as it is used in the trigger condition for TR1R it enables triggering in the selected time frame.

Softtrigger SOF2 has been set to a permanent logical 1 and as it is used in the trigger condition for TR2R this leads to a permanent enabling for triggering.

These conditions, expecially the logic operators, are to be put in in EDIT-mode. For explanation of EDIT mode, see Fig. 4.20.

If two or more channels use the same trigger sources defined by logic equations, this fact is indicated below the trigger condition lines by showing which channels are ´chained` (Fig. 4.24).

Trigger Menu is also used for setting parameters of extern trigger and arming input. This is to be done in the usual way by positioning cursor to the corresponding field and the SET-key - softkey procedure.

4.4.5. DISPLAY MENU

The display Menu gives the user entry to another special and unique feature of the PM3360 system. One has the possibility to make various automatic measurements on recorded waveforms. Twelve different measurements on amplitudes and fourteen different measurements on time are possible. Two measurement fields can be defined for each trace, but if one creates more traces from the same channel, e.g. the maximum of ten traces, then twenty different measurements can be recorded on a single waveform at the same time. In addition, a dimension name can be inserted, e.g. ´A` for ampere or ´DG` for degrees, which is very useful for documentation purposes. This is further supplemented by the possibility to set an amplitude multiplication factor. Operating procedure is again the same as with other menus by shifting cursor, pressing SET-key and using corresponding softkey. Fig. 4.25 demonstrates how the display menu looks like.

STATUS: DISPLAY MENU DEC 15. 16:03.13 LOCK

	----FIELD 1----			----FIELD 2----			AMPLITUDE
	MODE	AXIS	DIM	MODE	AXIS	DIM	FACTOR
TRAC01	■■■	AMPL	V	CUR	TIME	s	+1.0000
TRAC02	REF	AMPL	V	REF	TIME	s	+1.0000
TRAC03	TRIG	AMPL	V	TRIG	TIME	s	+1.0000
TRAC04	C-R	AMPL	V	C-R	TIME	s	+1.0000
TRAC05	C-T	AMPL	V	C-T	TIME	s	+1.0000
TRAC06	R-T	AMPL	V	R-T	TIME	s	+1.0000

MAT 1986

CUR	REF	TRIG	C-R	C-T	R-T	NEXT

Fig. 4.25 DISPLAY MENU (Select mode)

Two measurement fields are defined, each of them with the three parameters´ measurement (MODE), on which axis the measurement has to be performed, which means on amplitude or time axis (AXIS), and the dimension name field (DIM). This is completed by the amplitude factor field.
Each existing trace will be displayed in this menu and will get the C-R measurement in amplitude, in field 1 and in time direction in field 2 by default.

4.4.5.1 Mode selection

If you have set the cursor to the mode field (MODE), as it is shown in Fig. 4.25. and have pressed SET-key, the softkeys are relabeled with the names of the measurement modes. There will be cursor, reference cursor and trigger line absolut and relative, maximum, minimum, peak to peak, mean value, root measurements. Furthermore, the display can be switched off for one or both fields. Note that in the latter case the whole display line of this trace will vanish, so there will even be no trace = channel sign visible. For detailed description of the measurements see Table III.

One has to be aware every measurement is defined by use of the cursor. For example, if there is not a whole period of a waveform, calculation of frequency or RMS is not possible. Similar calculation of RMS is not possible, if the recorded signal exceeds the limits of the selected input range (ADC-range). These cases will be indicated by an "overrange" inserting in MEASURE Mode.

4.4.5.2 Axis selection

For definition of the axis, where the measurement has to be performed, the locator has to be shifted to the corresponding AXIS-field and SET-key to be pressed. Then the softkeys will be relabeled with amplitude (AMPL) and time (TIME) and the wanted axis can be selected by pressing one of them (Fig. 4.26).

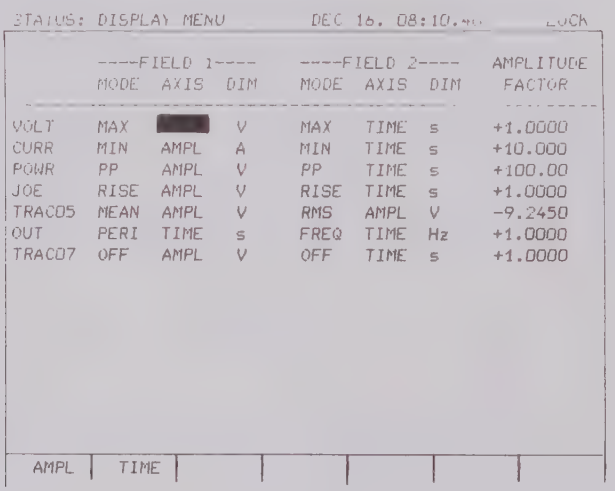

STATUS: DISPLAY MENU
DEC 16. 08:10.
----FIELD 1---- ----FIELD 2---- AMPLITUDE
MODE AXIS DIM MODE AXIS DIM FACTOR
VOLT MAX V MAX TIME s +1.0000
CURR MIN AMPL A MIN TIME s +10.000
POWR PP AMPL V PP TIME s +100.00
JOE RISE AMPL V RISE TIME s +1.0000
TRACO5 MEAN AMPL V RMS AMPL V -9.2450
OUT PERI TIME s FREQ TIME Hz +1.0000
TRACO7 OFF AMPL V OFF TIME s +1.0000
AMPL
TIME
MAT 1987

Fig. 4.26 DISPLAY MENU (Select axis)

4.4.5.3 Dimensions

A specific dimension can be put in the usual way by using keyboard #2.

4.4.5.4 Amplitude factor

The amplitude is automatically taken into account to the displayed value and can be used to take care of the measurement sensor used. As an example you can put in a multiplication factor of 10 and name the dimension as ´A`. This could describe a current measurement with a shunt of 0,1 Ohm and the displayed values are given directly in Ampere. It can also be used to compensate the attenuation factor of a probe.

Note: The amplitude factor does not influence the attenuation parameter in the upper left corner of the measure mode display. This means it is different from the attenuator (probe) factor in the input menu (Direct Mode).

For the definition of the amplitude factor, the cursor has to be placed in the amplitude factor field and Set has to be pressed. The softkeys are relabeled with some predefined values (see fig. 4.27).

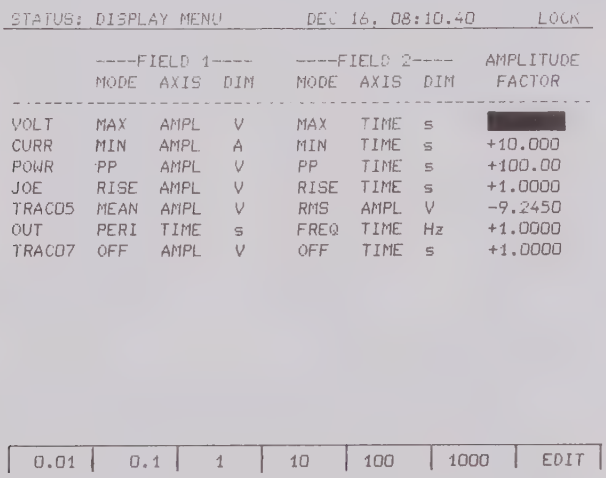


Fig. 4.27 DISPLAY MENU Select amplitude factor.

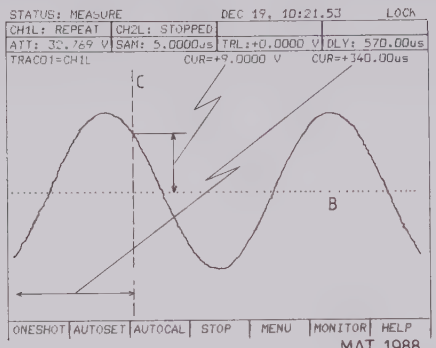
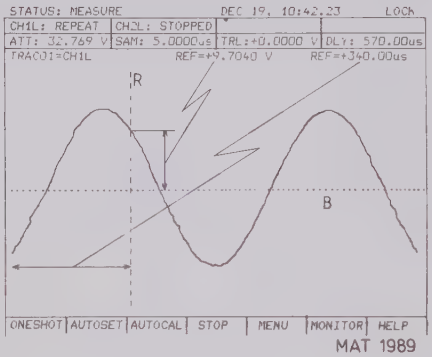
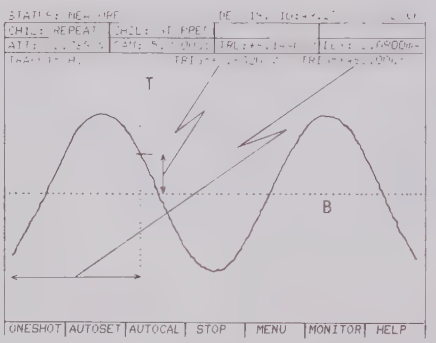
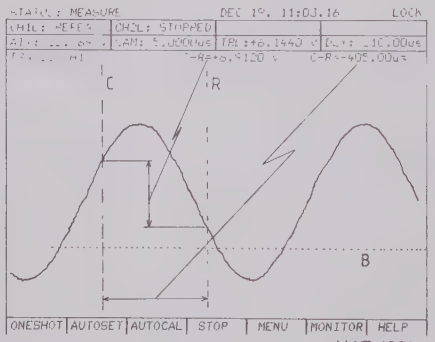
Mode	Description	Value displayed: Amplitude axis (Y)	Value displayed: Time axis (X)
CUR Cursor Absolut	 MAT 1988	CUR=...V Voltage between inter-section point of cursor and waveform and zero	CUR=...s Time between first re-corded point and cursor
REF Refer-ence Cursor Absolut	 MAT 1989	REF=...V Voltage between inter-section point of reference cursor and waveform and zero	REF=...s Time between first recorded point and reference cursor
TRIG Trigger Line Absolut	 MAT 1990	TRIG=...V Voltage of first recorded point after trigger and zero	TRIG=...s Time between first recorded point and trigger line
C-R Cursor minus refe-rence cursor	 MAT 1991	C-R=...V Voltage between inter-section points of cursor and reference cursor and waveform	C-R=...s Time between cursor and reference cursor

Table III) Description of measurements
(C=Cursor, R=Reference Cursor, T=Trigger Level, B=Baseline)

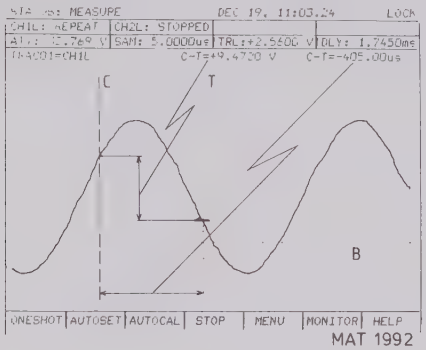
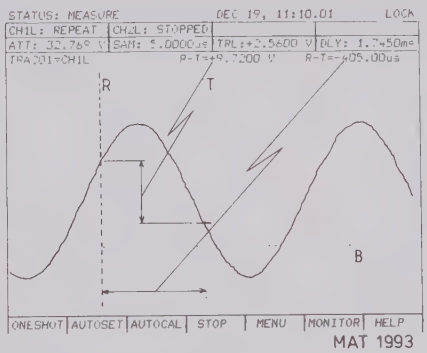
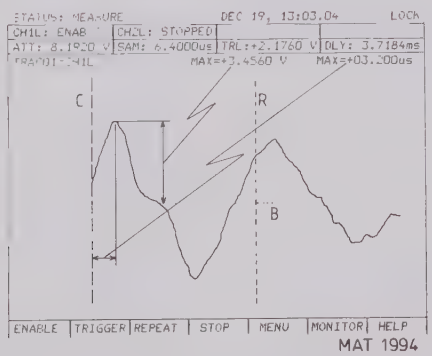
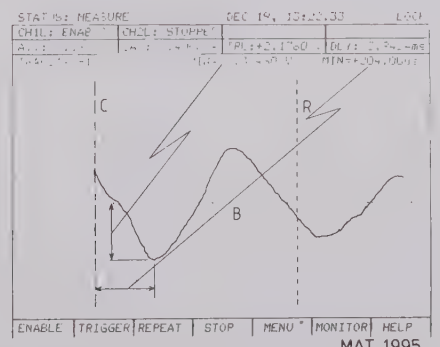
Mode	Description	Value displayed: Amplitude axis (Y)	Value displayed: Time axis (X)
C-T Cursor minus Trigger	 MAT 1992	C-T=...V Voltage between inter-section points of cursor and trigger line and waveform	C-T=...s Time between cursor and trigger line
R-T Trigger Line Absolut	 MAT 1993	R-T=...V Voltage between inter-section points of reference cursor and trigger line and waveform	R-T=...s Time between reference cursor and trigger line
MAX Maximum	 MAT 1994	MAX=...V Maximum voltage between cursor and reference cursor	MAX=...s Time between first recorded point of maximum
MIN Minimum	 MAT 1995	MIN=...V Minimum voltage between cursor and reference cursor	MIN=...s Time between first recorded point and minimum

Table III) Description of measurements (continued)
(C=Cursor, R=Reference Cursor, T=Trigger Level, B=Baseline)

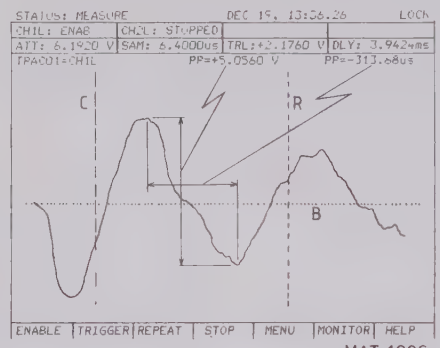
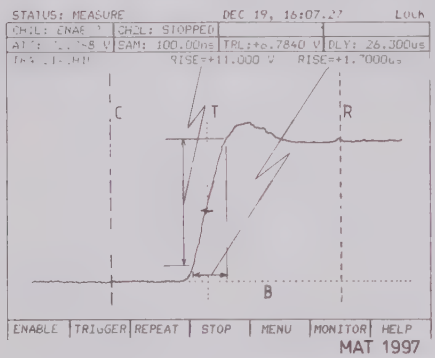
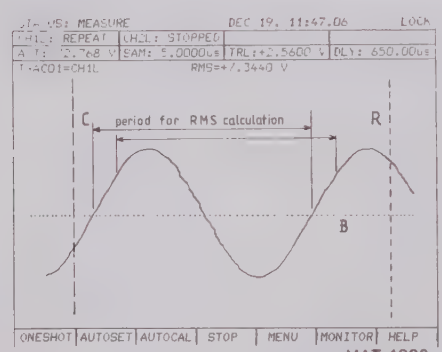
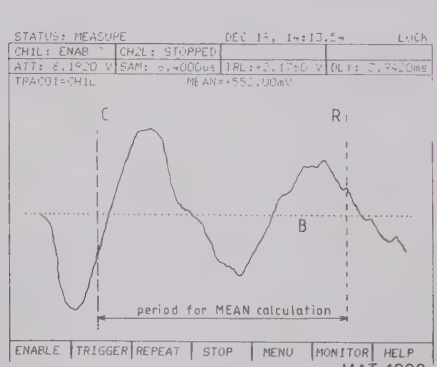
Mode	Description	Value displayed: Amplitude axis (Y)	Value displayed: Time axis (X)
PP Peak - Peak	 MAT 1996	PP=...V Peak to peak voltage between cursor and reference cursor	PP=...s Time between maximum and minimum
RISE Maximum	 MAT 1997	RISE=...V 10% to 90% voltage between cursor voltage and reference cursor voltage	RISE=...s Time between this 10% to 90% voltage
RMS Root mean square	 MAT 1998	RMS=...V Root mean square calculated on full periods between C and R (averaging on all full periods)	RMS=...s No time calculation
MEAN Mean value	 MAT 1999	MEAN=...V Mean value of waveform between cursor and reference cursor	MEAN=...s No time calculation

Table III) Description of measurements (continued)
(C=Cursor, R=Reference Cursor, T=Trigger Level, B=Baseline)

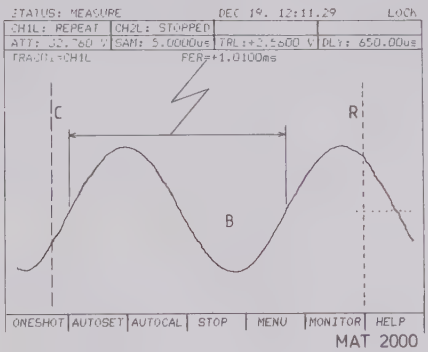
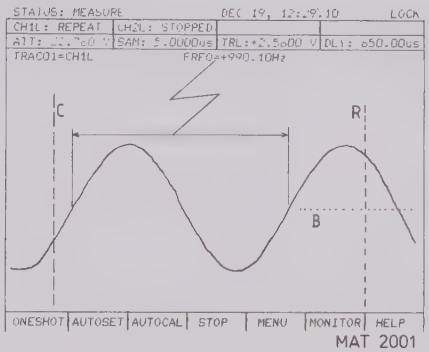
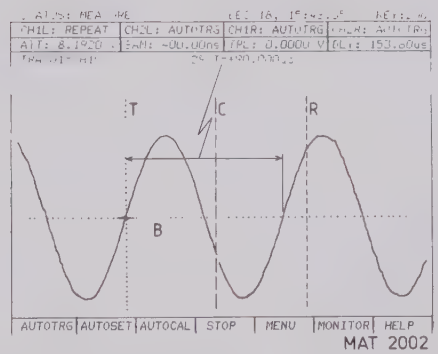
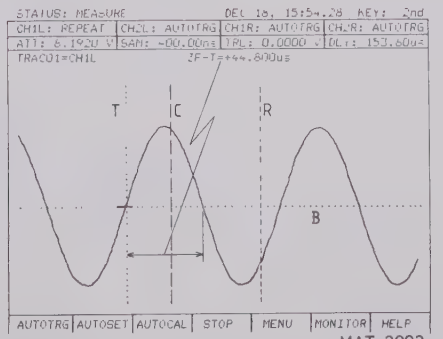
Mode	Description	Value displayed: Amplitude axis (Y)	Value displayed: Time axis (X)
PERI Period	 MAT 2000	No amplitude calculation	PERI=...s Period of waveform calculated on full periods between R and C (averanging on all full periods)
FREQ Fre- quency	 MAT 2001	No amplitude calculation	FREQ=...Hz Frequency of waveform calculated on full periods between R and C (Averaging on all full per.)
ZR-T Zero- Crossing to Trigger (rising slope)	 MAT 2002	No amplitude calculation	ZR-T=...s Time between Trigger line and first positive going zero crossing of waveform between cursor and reference cursor
ZF-T Zero- Crossing to Trigger (falling slope)	 MAT 2003	No amplitude calculation	ZF-T=...s Time between Trigger line and first negative going zero crossing of waveform between cursor and reference cursor

Table III) Description of measurements (continued)
(C=Cursor, R=Reference Cursor, T=Trigger Level, B=Baseline)

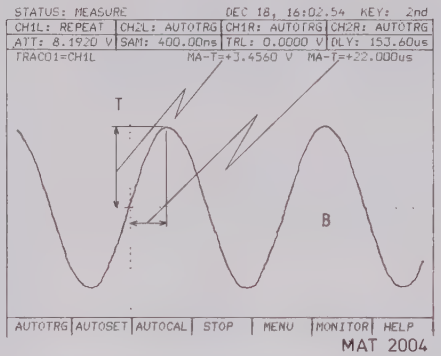
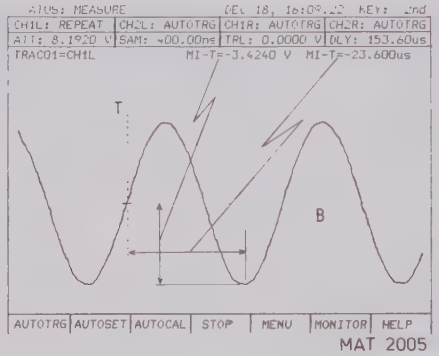
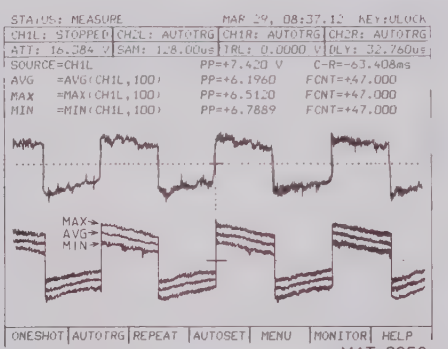
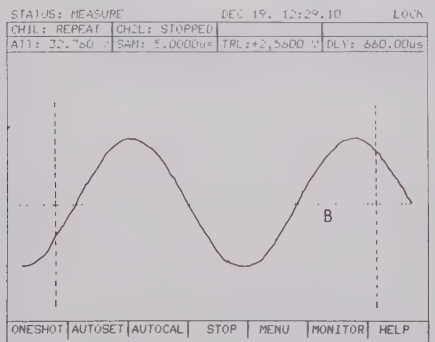
Mode	Description	Value displayed: Amplitude axis (Y)	Value displayed: Time axis (X)
MA-T Maximum to Trigger	 MAT 2004	Voltage difference between first recorded point after Trigger and Maximum	Time between Trigger and Maximum
MI-T Minimum to Trigger	 MAT 2005	Voltage difference between first recorded point after Trigger and Minimum	Time between Trigger and Minimum
FCNT Function Count	 MAT 2059	Actual number of recording, if origin is one of: AVG; MIN; MAX-AMSII functions 0 for all other origins	
OFF	 MAT 2006	Display switched off	

Table III) Description of measurements (continued)
(C=Cursor, R=Reference Cursor, T=Trigger Level, B=Baseline)

4.5. MONITOR MODE

Monitor mode offers a very modern and flexible way for read out and setting of PM3360 system variables using keyboard #2 or an external keyboard (optional) for programming the instrument.

The command syntax of this "Programmability" is BASIC-like, including a set of predefined variables which are representing the system parameters. These parameters can be read (used in a statement) and/or written (assignment of a value) by means of the BASIC-immediate mode (single line commands) or inside a complete BASIC-program.

The latter gives the user entry to the possibility to run the PM3360 under programming features like loops, conditional and unconditional transfers, use of subroutines, etc..
All data transfers, to or from external (optional) devices like Floppy disk, Non Volatile Memory, RS232 interface or Centronics interface are to be performed in Monitor Mode.

All these facilities are explained in detail in the "Programming Manual" of the PM3360.

4.5.1 Devices and Files

With your PM3360 you can use files, e.g. to store data or programs for future use.

<file>::=<device><name>.<type>

<file> describes a set of data

<device> describes the place, where to find data or where data has to be transfered.

4.5.1.1 Devices

The devices to which files can be send or from which files can be send or from which files can be fetched are not only physical devices like floppy disks or prrinters, but also imaginary devices like the memory part that contains the traces ore the settings.
A list of devices is given below:

```
Internal Floppy Drive A.................A:
Internal Floppy Drive B.................B:
External Floppy Drive C.................C:
External Floppy Drive D.................D:
Elektronic disc.........................E:
IEEE-488-Bus............................I:
Internal keyboard device................K:
Non volatile memory.....................N:
Internal CRT device.....................O:
Parallel output #1......................P:
Parallel output #2......................Q:
Set up device...........................S:
Traces device...........................T:
Serial interface bus (V24)#1............V:
Serial interface bus (V24)#2............W:
```

If <device> is not written, drive A (A:) is taken by default.

4.5.1.2 Files

<name> describes the file name

A filename consists of 1...8 characters and/or number and/or underline (no special characters).

Note: Trace names only have 1...6 characters etc.

<type> describes the filetype. A filetype consists of 0...3 characters etc. If one does not write a file type then the point (.) must not be written as well.

Examples for valid file name:

A: PROGRAM.BAS	Basic program on Floppy A
PROGRAM.BAS	Basic program on Floppy A (A is taken by default)
B: PROG_BAS.01	B: must be written
T: TRAC01	Traces have no free definable type (see below)
S:	Set ups and IEEE-488-Bus have no filename
I:	and typs

A Trace consists of a set of trace-amplitude data and set of corresponding data (parameter), e.g. date or colour of a trace. If no <type> is written data and parameters are both taken.

T: TRAC01.DAT	describes the amplitude data
T: TRAC01.PAR	describes the parameters
T: TRAC01	describes both amplitude data and parameters.

Each other sort of <type> is not valid.

4.5.1.3 Wildcards

A filename can be unambiguous or ambiguous. Is it unambiguous, one special file is described. An ambiguous filename describes several filenames.

A filename becomes ambiguous by using the question mark (?) or an asterix (*).

? means any character
* means any group of characters

Examples:

COPY "A:TRAC.1??" TO "T:TRAC.1??"
copies all files, which <type> begins with 1 and has two more characters

KILL "B:PROG.*"
delete all files which have the name "PROG" and any or no extension

KILL "B:*.*"
deletes all files on drive B:

* means all characters on his right side, therefore:

"PR*RAM.DAT" is illegal, but
"PR??RAM.DAT" is legal.

4.5.2 FORMAT Command

<format command>::=FORMAT[<drive>]

The format command is used for formatting of new diskettes. If drive is not written drive A is taken by default.

Example:

FORMAT B:
On the screen appears the question:
Erase all data on drive B? (Y/N)

4.5.3 DIRECTORY Command

<dir command>::=DIR[<drive>]

Gives a listing of the names etc. of all files stored on a diskette. If drive is written drive A is taken by default.

Example:

DIR B:
Name, type and Nr. of bytes of each file present on B appears.

4.5.4 SAVE Command

<save command>::=SAVE<file>

Saves a program file

Example:

SAVE "B:CALC.BAS"
Program is stored on drive B

SAVE "CALC.BAS"
program is stored on drive A by default

4.5.5. LOAD Command

<load command>::=LOAD<file>

Loads a program file into system memory

Example:

LOAD "B:CALC.BAS"
program is loaded from drive B

4.5.6 COPY Command

<copy command>::=COPY<file> to <file>

Copy a file from one device to another

Examples:

```
COPY "T:TRAC01" TO "B:SIGNAL"
stores trace "TRAC01" on drive B with filename SIGNAL

COPY "WAVEFORM" TO T:TRAC16"
loads trace "WAVEFORM" from drive A, and displays it as TRAC16

COPY "S:" TO "B:SET1"
store actual set-up on drive B

COPY "B:SET1" TO "S:"
load set-up "SET1"
```

Copy command can be completed by a switch "K" which suppresses the question.

```
xxx already exists, delete (Y/N)?
```

if the filename exists and deletes the old filename immediately.

Example:

```
COPY "T:TRAC01" TO "A:"K
```

Copy command can also be completed by a switch "Q" (Query-Switch). If this has been done an acknowledgement is necessary in any case.

Example:

```
>COPY "T:TRAC*" TO "A:" Q
COPY T:TRAC01 TO A:TRAC01(Y/N)Y
copied T:TRAC01 to A:TRAC01
```

Q and K-Switch can be used together. Q after K or K after Q, but they have to be distanced by blanks.

4.5.7 KILL Command

<kill command>::KILL<file>

Deletes a file.

Example:

```
KILL "B:SET1"
File SET1 is deleted from drive B
```

A Q-Switch can be used (see section 4.5.6).

4.5.8 RENAME Command

<rename command>::=RENAME<file> to <file>

Renames a file on same device

Example:

```
RENAME "T:TRAC01" TO "T:VOLT"
Name of TRAC01 is changed to VOLT on the display
```

A K-Switch and/or Q-Switch can be used (see section 4.5.6).

4.6. HELP FUNCTIONS

The PM3360 system is equipped with HELP-functions for easy operation. Pressing this HELP-key leads to the display of a built in operation manual. One will find explanations of one or more pages there, how to operate the instrument, how to select special values for parameters etc.

The user of a PM3360 should never hesitate to read the help descriptions for easy use and to get familiar with the instrument´s features.

The example shown in Fig. 4.28 is the explanation how to manipulate traces, one of the pages out of measure mode.

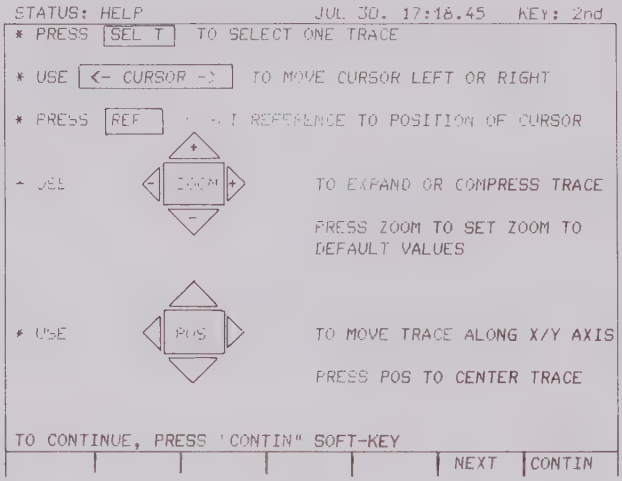


Fig. 4.28 HELP-fuctions (MEASURE mode)

In every page of the HELP function one will find softkeys relabeled with CONTIN, and if there are more pages to be found, with NEXT. Pressing NEXT will lead to another page. To return to the mode you have been working in, before calling the HELP-function, press continue key (CONTIN).

4.7. ADVANCED MATHEMATICAL SOFTWARE (AMSII)

4.7.1. Introduction

The AMS software package provides the capability to use high sophisticated waveform analyzing functions with your PM3360 system completing the possibilities of algebraic operations in your Base Unit. AMS incorporates functions like Averaging, Fast Fourier Transform, Differentiation, Integration, Correlation etc.

A special feature of your PM3360 system is that the mentioned functions are performed at run time which leads to a quick updata on screen.

Sources can be recorded as well as memorized data and most of the functions can even be used within expressions.

4.7.1.1 General

Call of functions is to be performed very simple by defining the origin of a trace in (General) Menu or by assigning an origin text string to the ORI$ system variable in the Monitor Mode.

Examples:

```
TRAC01 = INT(CH1L)
SIGNAL = AVG(CH2L, 100B)
FOURE  = FFT(SIGNAL)
```

As one can see channel names as well as trace names can be used in the source expressions.

4.7.1.2 Global used syntax definitions

The following syntax definitions are used to describe the syntax of functions in this sub-chapter. These definitions are described in detail in the Operating Manual PM3360.
These are the documentation conventions which are used throughout this section:

A | B | C	means that ONE of the terms separated by "|" has to be used
[ ]	means that the content of the brackets may be skipped.
[ ] ...	means that the content of the brackets may be repeated

Capital letters mean terminal symbols which have to be used in this form.

< >	means that the content is a non-terminal-symbol which is defined elsewhere
<< >>	means that the content is describing text and not part of the syntax.

The following lines give only a short overview:

```
<integer constant>::= [+|-]<digit string>

<real contstant>  ::= [+|-]<digit string>[.<digit string>]
                      [E[+|-]<digit string>]

<digit string>    ::= <digit>[<digit>]...

<digit>           ::= 0|1|2|3|4|5|6|7|8|9


<ori expr>        ::= [+|-]<ori term>[+|-<ori term>]...

<ori term>        ::= <ori factor> [*|/ <ori factor>]...

<ori factor>      ::= (<ori term>) | <ori const>|
                      <ori function> | <channel name> | <trace name>

<ori const>       ::= <real constant>

<channel name>    ::= CH1L | CH1R | CH2L | CH2R

<trace name>      ::= <char string>

<char string>     ::= <char>[<char>]...

<char>            ::= A|B|C|D|E|F|G|H|I|J|K|L|M|N|O|P|Q|R|S|T|U|V|W|
                      X|Y|Z|a|b|c|d|e|f|g|h|i|j|k|l|m|n|o|p|q|r|s|t|
                      u|v|w|x|y|z|_|
                      0|1|2|3|4|5|6|7|8|9

<ori function>    ::= <avg func> | <max func> | <min func> |
                      <dif func> | <int func> | <fft func> |
                      <acf func> | <ccf func> | <cut func> |
                      <smo func> | <apd func> | <frd func>
```

4.7.2 Signal Averaging (AVG)

4.7.2.1 Definition and Purpose

The AVG Function allows averaging of traces. This can be used to extract a periodical signal from noise components by improving signal-to-noise ratio. To perform meaningful averaging of time function, a trigger signal is needed for synchronisation. This trigger signal is used to maintain relative phase of the signal to be sampled.

When averaging is performed N times repeatedly, signal-to-noise ratio is improved by $\sqrt{N}$ times.

Data is averaged in your PM3360 system by using "arithmetic averaging":

$$y = \frac{1}{n} \sum_{i=0}^{n} x_i$$

The number of samples to be averaged can be defined by user in the range of 1 to 32767.

4.7.2.2 Use of AVG-Function

Averaging can be performed on a trace by editing the origin-field of the trace, using the following syntax (See also section 4.4.1. - "General menu").

Syntax of origin field:

<avg func>>:=AVG(<ori-expr-1>,<count> <avg-switch>)

<count> ::=<integer constant>

<avg-switch>::=[A|B][B|C]

Syntax description:

AVG	a three letter string identifying the average function.
(	an opening bracket
<ori-expr-1>	origin expression - subtype lan expression defining the source data origin, this can be any valid AMS expression which does not contain an average, maximum or minimum function itself.
,	a comma
<count>	an integer number, defining the number of samples to be averaged
<switches>	one or two characters, defining the special input and/or output mode. They can be omitted (=default settings)
)	a closing bracket

The following switches can be used:

A Take all input data samples for averaging (default)
N Take only input data samples with all points in A/D converters range and skip the rest. The skipped samples are not counted. Use of this switch guarantees that all points are the exact arithmetic average of the valid input data samples.
C Continuous output: refresh screen after each new sample is added to average accumulator. This mode is useful when averaging a large number of samples (default).
B Block output: refresh screen after a complete block of N samples was recorded and averaged.

Restart Averaging:

The Average Function can be initialized by the following:
- Editing the origin line in the general menu:
  Each time the origin line in the general menu is opened for editing by pressing the ´SET`-softkey the average function is initialized, regardless if there was a change in origin-text or not.
- By changing any parameter of the source, i.e. changing sample-rate, attenuator, delay, offset,...
- By assigning the commandstring "RESET" to the system variable FST$ (function status) in Monitor mode. Do not forget to assign a special average mode ("CONT","SHOT","BLOCK") to the FST$ system variable afterwards. See also Section 4.7.2.3.

Examples:

AVG (CH1L,100)
Averaging is done with data recorded by Channel CH1L. There are 100 samples taken and after the last of these samples is recorded, average buffer is cleared and averaging is restarted.
All input samples are taken for averaging and output is updated each time new sample is added to the accumulator (switches ´A` and ´C` are default).

AVG (CH1L*TRAC02, 200 N B)
Averaging is done on data computed by the expression CH1L*TRAC01. There are 200 samples taken. Only samples with all data in A/D-converters range are taken and counted (switch ´N`); all other samples are ignored. Output data is updated after the last sample was taken. So trace data on screen only changes after each 200 valid samples.

4.7.2.3 The display function FCNT and the system variable FST$

There are functions available to get information about the state of averaging, maximum search (section 4.7.3) and minimum search (section 4.7.4).

The FCNT display function:

The number of averages already performed, resp. the number of samples used for maximum- or minimum search can be displayed at runtime using the display funcion "FCNT". This is simply done by editing the function code in display menu or assigning the string "FCNT" to either the system variable "DM1$" or "DM2$" in Monitor Mode. For details see Programming Manual.

If you try to use the "FCNT" function on a trace not including either an AVG-,MAX- or MIN-function in its origin expression, the displayed value will always be zero.

The FST system variable:

The FST$ (function status) system variable is used in Monitor mode to get status information on an AVG-, MAX- or MIN- function, or to set special function modes. The following command-strings can be assigned to or returned by FST$:

"RESET"
This string can be assigned to FST$ only.
This command resets the AVG-, MAX- or MIN-function by setting the function counter to zero and clearing all internal buffers. After the reset is performed, the state is set to "IDLE".
The state is left at "IDLE", so you must assigne one of the special modes ("CONT", "BLOCK", "SHOT") to FST$,

"IDLE"
This string can be returned by FST$ only.
In this state the AVG-, MAX- or MIN- function ignores all new data. The contents of all internal buffers do not change, nor is the sample counter incremented.
In this state the sytem variable TDR% (trace-data-ready) will never change to one, indicating that there is no new outputdata computed.

"CONT"
This string can be assigned to and returned by FST$.
In this mode data is computed continously. After the last sample of one block was taken, the buffers are cleared and the samplecounter is reset to zero. This is the default mode. Each time an AVG-, MAX- or MIN- function is assigned to the origin of a trace either via (general) menu or by using the ORI$ system variable, the function mode is set to "CONT".

"BLOCK"
This string can be assigned to and returned by FST$.
In this mode only one block of n samples is taken; the function mode changes to "IDLE" the next time the function counter (as returned by the display function FCNT) reaches the maximum value defined in the origin string.
Note: Do not mix up this BLOCK mode and the Block output mode, defined by the switch B.

"SHOT"
This string can be assigned to and returned by FST$.
In this mode only one (valid) inputsample is taken. The function mode changes to "IDLE" after the next valid input sample was processed.

4.7.3. ´Maximum-hold` Function (MAX)

4.7.3.1. Definition and Purpose

The MAX-function allows recording of data maximum. This is used to get information about the maximum deviation of a signal from the averaged signal (MAX & MIN together with AVG). It can be used to determine the shape of a periodic signal from a noisy-input.

Data is computed by getting the maximum of each point.

The number of samples to be used for maximum search can be defined by user in the range of 1 to 32767.

4.7.3.2. Use of MAX-Function

´Maximum-hold` can be performed on a trace by editing the origin-field of the trace, using the following syntax (See also section 4.4.1 - "General menu")

Syntax of origin-field:

<max func>::= MAX(<ori-expr-1>,<count> <max switch>)

<count> ::= <integer constant>

<max-switch>::= [A|N][B|C]

Syntax description:

MAX	a three letter string identifying the maximum function.
(	an opening bracket
<ori-expr-1>	origin expression -subtype 1 an expression defining the source data origin, this can be any valid AMS expression which does not contain an average, maximum or minimum function itself.
,	a comma
<count>	an integer number, defining the number of samples to be sampled.
<switches>	on or two characters, defining the special input and/or output mode. They can be omitted (=default settings)
)	a closing bracket

The following switches can be used:

A Take all input data samples (default)
N Take only input data sample with all points in A/D-converters range and skip the rest. The skipped samples are not counted. Using this switch guarantees that all points are the exact arithmetic average of the valid input data samples.
C Continuous output: refresh screen after each new sample is added to average accumulator. This mode is useful when averaging a large number of samples (default).
B Block output: refresh screen after a complete block of N samples was recorded.

Restart ´Maximum-Hold`:

The Maximum Hold function can be initialized by the following:
- Editing the origin line in the general menu:
  Each time the origin line in te general menu is opened for editing by pressing the ´SET`-Softkey the maximum hold function is initialized, regardless if there was a change in origin-text or not.
- By changing any parameter of the source, i.e. changing sample-rate, attenuator, delay, offset,...
- By assigning the commandstring "RESET" to the system variable FST$ (function-status) in monitor mode. Do not forget to assign a special function mode ("CONT", "SHOT", "BLOCK") to the FST$ system variable afterwards. For details see section 4.7.2.3.

Examples:

MAX (CH1L,100)
Maximum hold function is performed with data recorded by Channel CH1L. There are 100 samples taken and after the last of these samples is recorded, maximum hold buffer is cleared and the function is restarted.
All input samples are taken for maximum search and output is updated each time a new sample is recorded. (switches ´A` and ´C` are default)

MAX (CH1L*TRAC02, 200 N B)
Maximum hold function is performed on data computed by the expression CH1L*TRAC02. There are 200 samples taken. Only samples with all data in A/D-converters range are taken and counted (switch ´N`); all other samples are ignored. Output data is updated after the last saple was taken; so trace data on screen only changes after each 200 samples.

4.7.4. ´Minimum-hold` Function (MIN)

4.7.4.1. Definition and purpose

The MIN-function allows recording of data minimum. This is used to get information about the maximum negative deviation of a signal from the averaged signal (MAX & MIN together with AVG). It can be used to determine the shape of periodic signal from a noisy-input.

Data is computed by getting the minimum of each point.

The number of samples to be used for minimum search can be defined by user in the range of 1 to 32767.

4.7.4.2. Use of MIN-Function

´Minimum-hold` can be performed on a trace by editing the origin-field of the trace, using the following syntax (See also section 4.4.1. - "General menu").

Syntax of origin field:

<min func>::= MIN<ori-expr>,<count> <min switches>)

<count> ::= <integer constant>

<min-switch>::= [A|N][B|C]

Syntax description:

MIN	a three letter string identifying the minimum function.
(	an opening bracket
<ori-expr-1>	origin expression - subtype 1 an expression defining the source data origin, this can be any valid AMS expression which does not contain an average, maximum or minimum function itself.
,	comma

<count> an integer number, defining the number of samples to be sampled.

<switches> one or two characters, defining the special input and/or output mode. They can be omitted (=default settings).

) a closing bracket

The following switches can be used:

A Take all input data samples (default)
N Take only input data samples with all points in A/D converters range and skip the rest. The skipped samples are not counted. Using this switch guarantees that all points are the exact arithmetic average of the valid input data samples.
C Continuous input: refresh screen after each new sample is added to average accumulator. This mode is useful when averaging a large number of samples (default).
B Block output: refresh screen after a complete block of N samples was recorded.

Restart Minimum Hold:

The minimim hold function can be initialized by the following:
- Editing the origin line in the general menu:
  Each time the origin line in the general menu is opened for editing by pressing the ´SET`-Softkey the minimum hold function is initialized, regardless if there was a change in origin-text or not.
- By changing any parameter of the source, i.e. changing sample-rate, attenuator, delay, offset, ...
- By assigning the commandstring "RESET" to the system variable FST$ (function-status) in monitor mode. Do not forget to assign a special function mode ("CONT", "SHOT", "BLOCK") to the FST$ system variable afterwards. For details see section 4.7.2.3.

Examples:

MIN (CH1L,100)
Minimum hold function is performed with data recorded by Channel CH1L. There are 100 samples taken and after the last of these samples is recorded, minimum hold buffer is cleared and the function is restarted.
All input samples are taken for minimum search and output is updated each time a new sample is recorded (switches ´A` and ´C` are default)

MIN (CH1L*TRAC02, 200 N B)
Minimum hold function is performed on data computed by the expression CH1L*TRAC02. There are 200 samples taken. Only samples with all data in A/D-converters range are taken and counted (switch ´N`); all other samples are ignored. Output data is update after the last sample was taken; so trace data on screen only changes after each 200 samples.

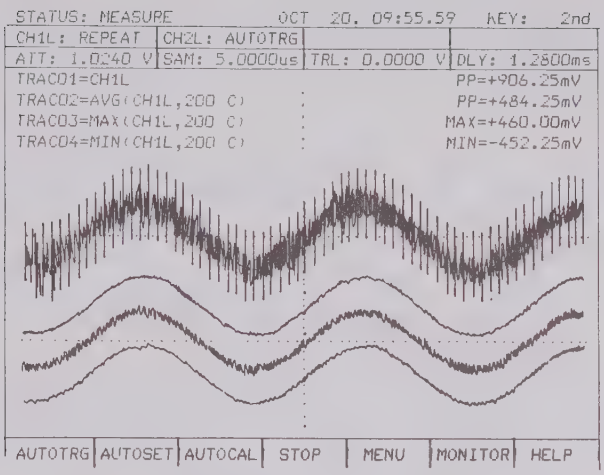


Fig. 4.29 Averaging, Maximum- and Minimum Hold functions.

4.7.5. Differentiation (DIF)

4.7.5.1. Definition and Purpose

The DIF-function is used to calculate the differentiated function in time domain, as expressed by the formula

$$Y = \frac{d}{dt} X$$

One can use this function to record and view directly a differentiated function, for example s/st I value of the current in a switching unit.

Function data is computed by evaluating the differential coefficient between N points.

4.7.5.2. Use of DIF-Function

Differentiation can be performed on a trace by editing the origin-field of the trace, using the following syntax (See also section 4.4.1. - "General menu").

Syntax of origin-field:

<dif func>::=DIF(<ori-expr>[,[<count>][,scale]])

<count> ::= <integer constant>

<scale> ::= <real constant>

Syntax description:

DIF — a three letter string identifying the differentiation.

(— an opening bracket

<ori-expr> origin expression:;
an expression defining the source data origin, this can be any valid AMS expression which may include a DIF statement itself (nested differentiation is possible).

, a comma

<count> An integer number, which gives the number of data points which are taken for piecewise averaging. This leads to a digital filtering of the computed waveform. See Fig. 4.30 for detail. This number can be omitted together with the preceeding comma, resulting in a default setting for count. Default value is (Points-per-trace/64).
If your signal is periodical, you can smooth the picture of the differentiated trace not only by increasing count, but also by averaging. Averaging results in a faster impuls response (steeper edges on change of source gradient).

, a comma

<scale> A real number defining the maximum value of the resulting trace, which is guaranteed to be in range. Due to the internal representation of trace data in integer notation, the real full-scale value can be bigger than this scaling parameter.

) a closing bracket

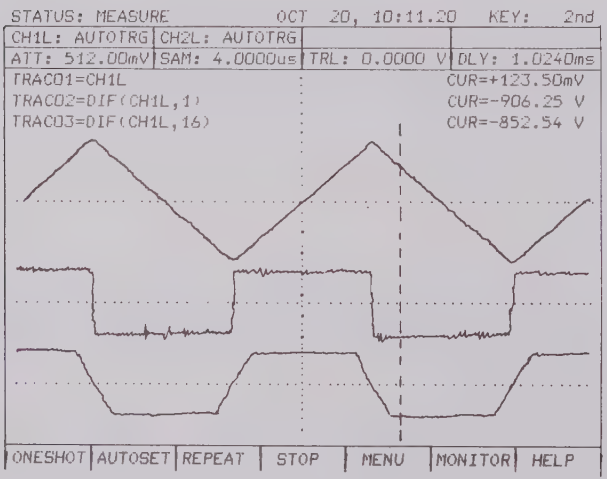


Fig. 4.30 Differentiation of Waveform and Digital Filtering.

4.7.6 Integration Function (INT)

4.7.6.1 Definition and Purpose

Integration of signals is defined by the formula

$$Y_t = \int_0^t x(t)dt + c$$

As seen from the formula above, the mathematical function consists of an integral part and a constant.

4.7.6.2 Use of INT-Function

Integration can be performed on a trace by simply editing the origin-field of the trace, using the following syntax (See also section 4.4.1. - "General menu).

Syntax of origin-field:

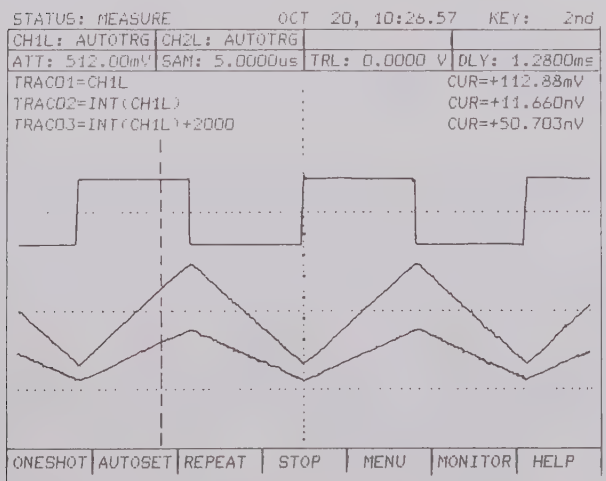
<int func>::= INT(<ori-expr>[,[<offset>][,<scale>]

<offset> ::= <real constant>

<scale> ::= <real constant>

Syntax description:

INT	a three letter string identifying the integral function.
(	an opening bracket
<ori-expr>	origin expression; an expression defining the source data origin, this can be any valid AMS expression which may include an INT statement itself (nested integration is possible).
,	a comma
<offset>	a real constant, defining an optional integration constant to be added. If omitted, the intergration constant is assumed to be zero.
,	a comma
<scale>	A real number defining the maximum value of the resulting trace, which is guaranteed to be in range. Because trace data is in integer notation, the real full-scale can be bigger than this scaling parameter.
)	a closing bracket



MAT 2011

Fig. 4.31 Integration

4.7.7. The Fast Fourier-Transformation (FFT)

4.7.7.1. Definition and Purpose

The FFT-Transformation computes the Fourier spectrum using the transformation formula

$$S(f) = \int_{-\infty}^{+\infty} x(t)\, e^{-j2\pi ft}\, dt$$

In general, when t and f are used as time and frequency variabels respectively, x(t) is expressed as S(f) in the frequency domain, as far as x(t) is a real function of time. x(t) is not necessarily a periodical function. S(f) includes amplitude and phase information at all frequencies of x(t). S(f) can be expressed several forms:

formula 1 $$S(f) = \sum_{j=-\infty}^{+\infty} c_j \cos(2\pi nft + \varphi_j)$$

formula 2 $$S(f) = \sum_{j=-\infty}^{+\infty} a_j \cos(2\pi nft) + b_j \sin(2\pi nft)$$

4.7.7.2. Frequency Span and Resolution

As the PM3360 samples input data at a specified sampling rate t_s, the highest frequency which can be computed in the frequency domain is

$$fmax = \frac{1}{2*t_s}$$

resulting from Shannon´s theorem. On the other side the frequency resolution is resulting from the assumption, that the source signal in time domain is periodical with the record length used for computing the FFT.
So the resolution f_Δ is expressed by

$$f_\Delta = \frac{1}{2*t_s*N}$$

where N is the number of samples used.

It is very important to remember this assumption, when using the FFT, not only because of the frequency resolution, but also because of an other effect, called the "leakage effect". It is discussed in section 4.7.7.4.

4.7.7.3. Use of the FFT-Transformation

Frequency transformation can be performed on a trace by editing the origin-field of the trace, using the following syntax (See also section 4.4.1. - "General Menu").

Syntax of origin-field:

<fft func> ::= FFT(<ori-expr-2>[,<fft-switches>])

<fft-switches>::= [F|H][R|K][[N][A|P|C|S]|[P][A]]

Syntax description:

FFT	a three letter string identifying the FFT-transformation
(	an opening bracket
<ori-expr>	origin-expression-subtype 2 an expression defining the source data origin, this can be any valid AMS expression, which does no contain any of the following functions: FFT, ACF, CCF
,	a comma
<fft-switches>	one to four characters, defining the output format and the window function. Omitting a switch selects the default value.
)	a closing bracket

The following switches can be used:

F no window function (default)
H Hanning window function
R real spectrum (only positive frequencies)
K complex spectrum (positive and negative frequencies) (default)
N linear amplitude scaling (default)
E logarithm (invers exponential) scaling of amplitude (read values in dB)
A amplitude spectrum (default)
display c_j from formula 1.
P phase spectrum
display φ_j from formula 1.
C cosine spectrum ("real part spectrum")
display a_j from formula 2.
S sinus spectrum ("complex part spectrum")
display b_j from formula 2.

There are some combinations of switches that are not legal like:

PE, CE, SE.

Note the following restrictions:
The length of FFT transformation is limited to 4096 points of source (origin) data resulting in a 4096 line complex or 2048 line real spectrum. Trying to perform a FFT on a longer source data block results in a ´RUNTIME EXCEPTION`!

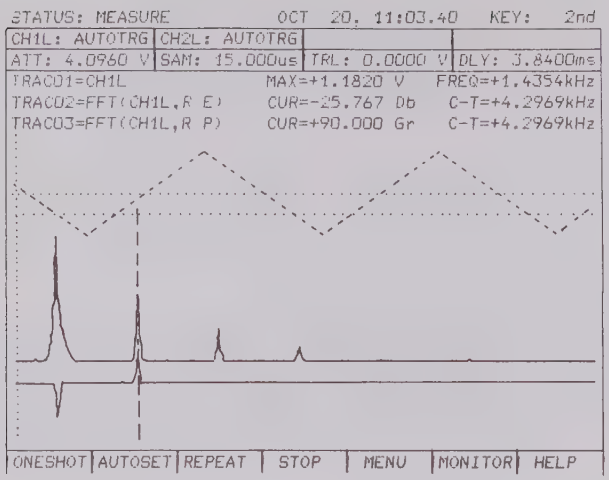

STATUS: MEASURE OCT 20, 11:03.40 KEY: 2nd
CH1L: AUTOTRG CH2L: AUTOTRG
ATT: 4.0960 V SAM: 15.000us TRL: 0.0000 V DLY: 3.8400ms
TRACO1=CH1L MAX=+1.1820 V FREQ=+1.4354kHz
TRACO2=FFT(CH1L,R E) CUR=-25.767 Db C-T=+4.2969kHz
TRACO3=FFT(CH1L,R P) CUR=+90.000 Gr C-T=+4.2969kHz
ONESHOT AUTOSET REPEAT STOP MENU MONITOR HELP
MAT 2012

Fig. 4.32 FFT (Amplitude and Phase Spectrum)

4.7.7.4. Special Topics of Frequency Transformation

When using the FFT and the other frequency transformation functions implemented in the PM3360 including correlation measurements, you should always bear in mind the following restrictions and effects:

The Leakage Effect

Because of the time signal used for frequency transformation is assumed periodical with the record length as period, there is an error in computing the FFT, if the record does not contain a multiple of full cycles of the source signal. There are two ways to reduce this effect:

- record a large number of periods of source signal. The effect discreases with a higher number of cycles recorded.
- use of Hanning window function (see Fig. 4.33).

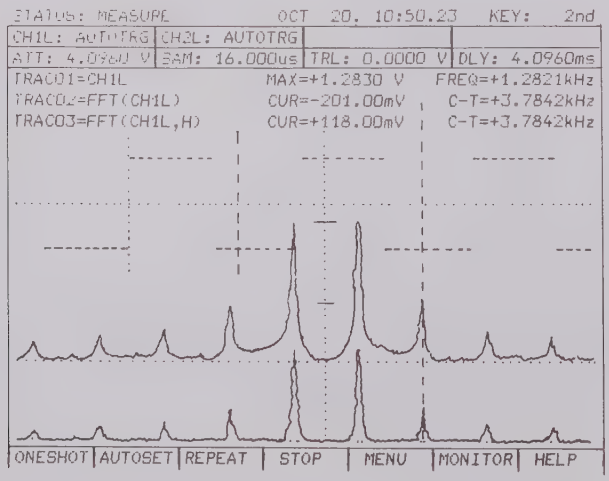

STATUS: MEASURE OCT 20, 10:50.23 KEY: 2nd
CH1L: AUTOTRG CH2L: AUTOTRG
ATT: 4.0960 V SAM: 16.000us TRL: 0.0000 V DLY: 4.0960ms
TRACO1=CH1L MAX=+1.2830 V FREQ=+1.2821kHz
TRACO2=FFT(CH1L) CUR=-201.00mV C-T=+3.7842kHz
TRACO3=FFT(CH1L,H) CUR=+118.00mV C-T=+3.7842kHz
ONESHOT AUTOSET REPEAT STOP MENU MONITOR HELP
MAT 2013

Fig. 4.33 FFT (Fourier Transformer and Hanning Function)

Source Length

The length of the source expression should be a number 2 to the power of n (128, 256, 512, 1024, ..., 4096).

Only source lengths of this form are transformed directly.

Other source lengths are converted to the next higher length of the form 2^n. Additional data is taken from the first samples, assuming periodicy again. This might increase the leakage effect. The accuracy decreases with the source length differing from 2^n.

4.7.7.5 Interpretation of tracedata using FFT

Using FFT transformation results in transforming recorded data from time- into frequency domain. The X- and Y-axis must be interpreted different in frequency domain than in time domain (normal y-t display):

Y-axis: Amplitude linear or logarithm scaled

X-axis: frequency axis

This fact is very important to be considered when defining display field functions. So for example trying to display "FREQ" on a trace with an FFT origin will result in an erronous (and unexpected) result!

To display correct values follow the guidelines below:

- measuring amplitude values:

  linear scale:
  Scaling is done in "V" ("VOLT") or equivalent units, such as it is done in time domain display. So you can use all display functions reffering to amplitude only.

  logarithm scale:
  Scaling is done in dB (dezibel). 0dB is fixed to the full scale value defined by origin data. For origins consisting of a single channel name only this means that 0dB are set to "attenuator-level / 2".
  The smallest level, that can be displayed is fixed to approximately -42dB.
  Due to logarithm scaling, you can only use displays that directly show amplitude values ("CUR", "C-T", "C-R" ...).

- measuring frequency values:

  Frequency is scaled in ´Hz` (´Hertz` or ´cycles per second`) on "TIME" axis. The zero-frequency point (DC) is located at the trigger line position. So to measure absolute frequency at the cursor position use the display function "C-T" on "TIME" axis and interprete the display as Hz. For measuring absolute frequency at the reference cursor position use "R-T" on "TIME" axis. Relative frequency measurements can be performed by "C-R" display on "TIME" axis.
  Any other function ("RMS", "MEAN", ...) must not be used! Remember that the "FREQ" display function must not be used for displaying frequencies in any case!

To display the frequency of the component with the maximum level use display function "MA-T" or "MI-T" on "TIME" axis. For displaying the amplitude value of those frequency components use "MAX" or "MIN" on "AMPL" axis.

4.7.8. The Auto Correlation Coefficient Function (ACF)

4.7.8.1. Definition and Purpose

The auto correlation AC is defined by the expression

$$AC(\ ) = \int_{-\infty}^{+\infty} x(t).x(t+\tau)dt$$

The function implemented in the PM3360 AMS-software package computes the normalized auto correlation coefficient

$$ACF(\tau) = \frac{AC(\tau)}{AC(0)}$$

Auto correlation is a function of time difference τ, and may be used to analyze the nature of irregular signals or to extract a periodical signal from irregular signals by coefficient takes the maximum value at =0, which is normalized to "1".

4.7.8.2. Use the ACF-Function

Computation of the auto correlation coefficient can be performed on a trace by editing the origin-field of the trace, using the following syntax (see also Section 4.4.1. - "General Menu").

Syntax of origin field:

<acf-func> ::= ACF (<ori-expr-2>[,<acf-switch>])

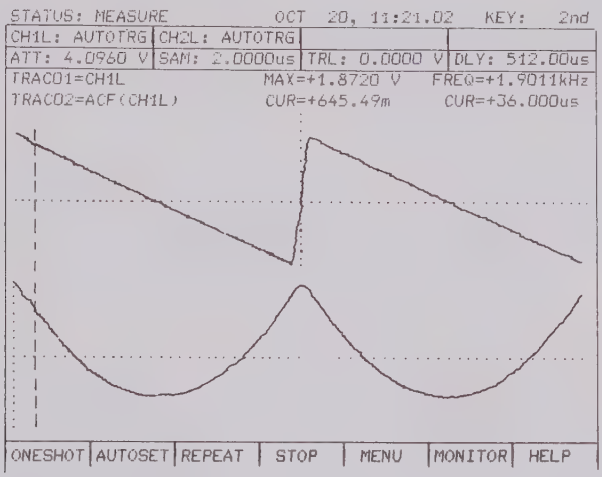
<acf-switch>::= Z

Syntax description:

ACF	a three letter string identifying the auto correlation coefficient function.
(	an opening bracket
<ori-expr-2>	origin expression - subtype 2 an expression defining the source data origin, this can be any valid AMS expression, which does not contain any of the following functions: FFT, ACF, CCF
,	a comma
<acf-switch>	zeropadding can be selected by adding the Z-switch
)	a closing bracket

The auto correlation function distinguishes between periodic and non periodic signals. If the zeropadding switch is used, a record of all zero is appended to the data recorded, indicating non periodic signal. Note the following restriction on source length:
The length of ACF tranformation is limited to 4096 points of source data without using the zeropadding switch or to 2048 points of source data using the zeropadding switch. Trying to compute ACF on a longer results in a RUNTIME EXCEPTION.

See also section 4.7.7.4.



MAT 2014

Fig. 4.34 Auto Correlation Function of a sawtooth

4.7.9 The Cross Correlation Coefficient Function (CCF)

4.7.9.1 Definition and Purpose

The cross correlation CC is defined by the expression

$$CC(\ ) = \int_{-\infty}^{+\infty} x(t)\ Y(t+\tau)\ dt$$

The function implemented in the PM3360 AMSII software package computes the normalized cross correlation coefficient

$$CCF(\tau) = \frac{CCF(\tau)}{AC_1(0).AC_2(0)}$$

where $AC_1(0)$ [$AC_2(0)$] is the auto correlation of signal 1 [2] with $\tau=0$.

Cross correlation coefficient function is used to determine the correlation between two points on two signals each, which are apart from each other by time difference τ. It is used to determine velocity of distance by delay time measurement or to determine propagation paths of signals.

4.7.9.2 Use the CCF-Function

Computation of the cross correlation coefficient can be performed on a trace by editing the origin-field of the trace, using the following syntax (see also section 4.4.1. - "General Menu").

Syntax of origin field:

<ccf func> ::= CCF(<ori1-expr>,<ori2-expr>[,<ccf-switch>])

<ori1-expr> ::= <ori-expr-2>

<ori2-expr> ::= <ori-expr-2>

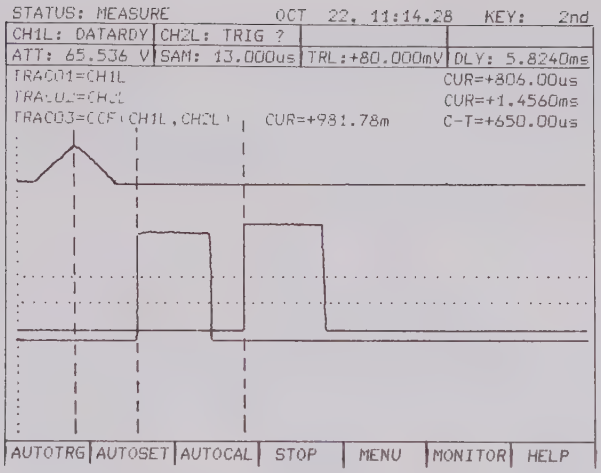
<ccf-switch>::= Z

Syntax description:

CCF	a three letter string identifying the cross correlation coefficient function
(	an opening bracket
<ori1-expr>	origin-expression sybtype 2 of first operand an expression defining the source data origin, this can be any valid AMS expression, which does not contain any of the following functions: FFT, ACF, CCF
,	a comma
<ori2-expr>	origin-expression subtype 2 of second operand same as above
,	a comma
<ccf-switch>	zero padding can be selected by adding the Z-switch
)	a closing bracket

The cross correlation function distinguishes between periodic and non periodic signals. If the zeropadding switch is used, a record of all zero is appended to the data recorded, indication non periodic signal.

Note the following restriction on source length:
The length of CCF transformation is limited to 4096 points of source data without using the zeropadding switch or to 2048 points of source data using the zeropadding switch. Trying to compute CCF on a longer origin results in a RUNTIME EXCEPTION. See also section 4.7.7.4.



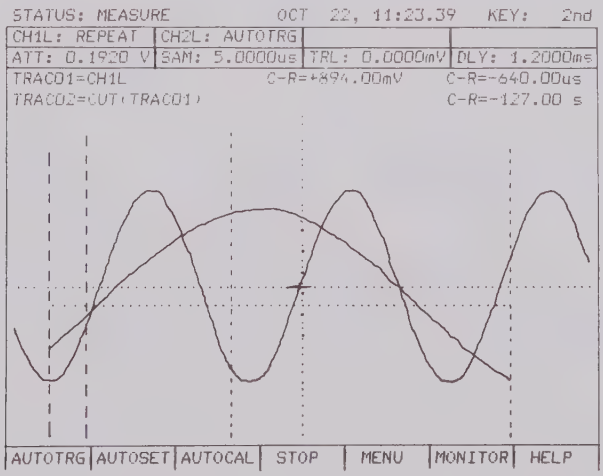
MAT 2015

Fig. 4.35 Cross Correlation Function of delayed Pulse

4.7.10 The CUT Function

4.7.10.1 Definition and Purpose

The CUT-function is used to extract a part of a trace and to copy this data to another trace at runtime. When using the function CUT all data between the cursor and the reference cursor is copied from the source trace to the destination.



MAT 2016

Fig. 4.36 CUT Function

If the reference cursor is optioned at the left side of the cursor then data is copied from reference cursor to cursor position.

4.7.10.2 Use of CUT-function

The CUT function can be performed on a trace by editing the origin-field of the trace, using the following syntax (See also section 4.4.1. - "General Menu").

Syntax of origin field:

<ori-func>::= CUT (<trace-name>)

Syntax description:

CUT	a three letter string identifying the CUT-function
(	an opening bracket
<trace-name>	name of another trace already defined.
)	a closing bracket

You can use the CUT-function to perform any other AMS transformation on a part of the source trace by simply typing (for example)

```
INT (CUT(TRAC01))
```

Note: When using the CUT function together with frequency transformations you should consider the facts described in section 4.7.7.4.

4.7.11 The Smoothing Function (SMO)

4.7.11.1 Definition and Purpose

The SMO-function is used to smoothen the picture of a recorded trace by performing piecewise averaging over a number of points. Each point of the resulting trace is defined by:

$$Y_j = \frac{1}{2n+1} \sum_{i=j-n}^{j+n} x_i$$

with x_i as the source data.

4.7.11.2 Use of smoothing function

Computation of the smoothing function can be performed by editing the origin-field of the trace using the following syntax (See also Section 4.4.1. - "General Menu").

Syntax of origin field:

<smo func> ::= SMO (<ori-expr>[,<smo-const>])

<smo-const>::= <integer constant>

Syntax description:

SMO	a three letter string identifying the smoothing function
(	an opening bracket
<ori-expr>	origin expression; an expression defining the source data origin

, a comma

<smo-const> an integer number, defining the number of points to be taken for averaging before and after the current position. The total number of points to be averaged about is defined by N=2*<smo-const>+1. If omitted, <smo-const> defaults to three, which is equal to a seven-point-average.

) a closing bracket

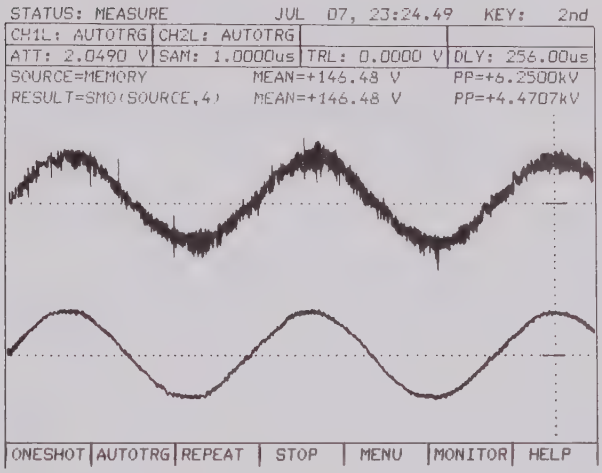


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Fig. 4.37 SMO function

4.7.12 The Amplitude Probability Function (APD)

4.7

4.7.12.1 Definition and Purpose

The APD-Function computes the probability of the source data to reach a special amplitude value. This function is useful to determine the nature of a signal, especially for statistical (random) signals. The ADP-function is defined by

$$Y = \frac{\text{number of occurances of amplitude i}}{\text{total number of origin points}} * 100$$

and scaled in percent.

4.7.12.2 Use of APD-Function

Computation of the APD function can be performed by editing the origin-field of the trace using the following syntax (See also Section 4.4.1. - "General Menu").

Syntax of origin field:

<apd func>::= APD(<ori-expr>[,<scale>])

<scale> ::= <integer constant>

Syntax description:

APD	a three letter string identifying the APF Function
(	an opening bracket
<ori-expr>	origin expression; an expression defining the source data origin
,	a comma
<scale>	an integer constant defining the full-scale value to be used (in percent). If omitted, the auto-scaling is selected and the APD function cannot be used together with the average, maximum or minimum functions.
)	a closing bracket

4.7.12.3 Interpretation of tracedata using the APD Function

Using the APD function results in transforming recorded tracedata from time into amplitude domain. The X- and Y- axis must be interpreted in a different way then in normal Y-t display mode:

Y - axis: probability in percent

X - axis: amplitude scale

This fact is very important to be considered when defining display field functions.

To display correct values follow the guideline below:

- measuring percental probabilities
  Scalling of probability is always done in percent (%). Use only functions that display absolute or differential values, for example "CUR", "REF", "C-R" ... on "AMPL"(!) axis.

- measuring amplitude values
  Amplitude is displayed at TIME (!!!) axis. Use only functions that display absolute or differential values, for example "CUR", "C-R", "MAX" ... on "TIME" axis.
  You must display amplitude values on TIME axis when using this function!

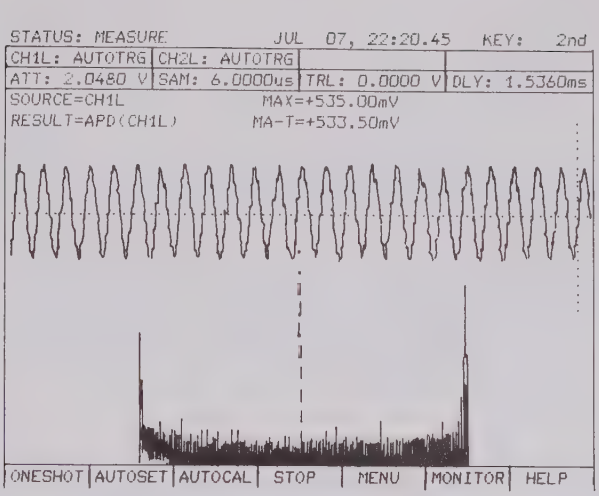

Fig. 4.38 APD Function

4.7.13 The Frequency Demodulation Function (FRD)

4.7.13.1 Definition and Purpose

The FRD Function computes the deviation of the frequency of one period from the medium frequency. The medium frequency of source data is computed by counting the number of positive crossings of the "zero-line" (the "zero-line" is that level defined by the offset parameter) and measuring the time between the first and the last (positive) crossing. The frequency deviation is calculated for all full periods of source signal, resulting in a constant value for each period. The value computed is the percental deviation of the frequency of this single period from the mean frequency as defined by

$$Y = \frac{\Delta f}{f_m} * 100$$

4.7.13.2 Use of FRD Function

The FRD function can be easily performed on a trace by simply editing the origin field of the trace using the following syntax. (See also Section 4.4.1. - "General Menu").

<frd-func>::= FRD(<ori-expr>[,[<scale>][,[<offset>][,<hyst>]]])

<scale> ::= <integer constant>

<offset> ::= <real constant>

<hyst> ::= <real constant>

Syntax description:

FRD	a three letter string identifying the FRD Function
(	an opening bracket
<ori-expr>	origin expression; an expression defining the source data origin
,	a comma
<scale>	an integer constant defining the full-scale value to be used (in percent). If omitted, scale defaults to 100%.
,	a comma
<offset>	a real constant, defining the level at which the "zero-crossing" should be detected. This is useful, if the signal has a DC-component.
,	a comma
<hyst>	a real constant, defining an optional hysteresis to be used. The "zero-crossing" is detected at the levels offset +/- hyst.
)	a closing bracket

The resulting trace data is set to zero from the beginning of the trace till the first valid (positive) "zero-crossing" and from the last valid (positive) "zero-crossing" till the end of the trace. This can lead to an unexpected ZERO line result if <offset> and/or <hyst> are choosen in a wrong way and there are not found at least two positive "zero-crossings".

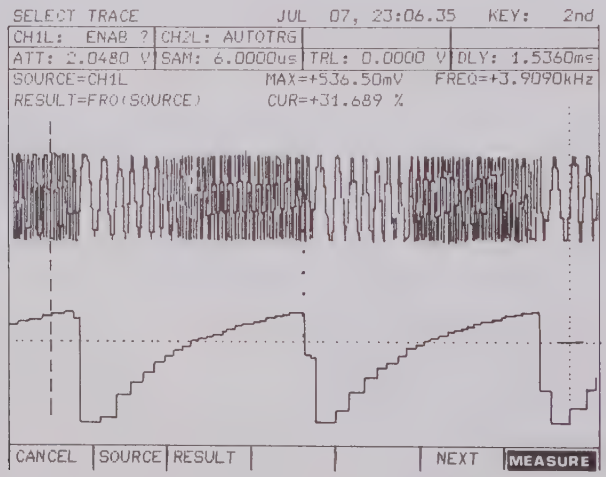

Fig. 4.39 FRD function

4.8 TECHNICAL DESCRIPTION

4.8.1 Fundamentals

AN ANALOG SCOPE
With an analog scope the electron beam is started on the left side of the screen, that means that the visible information shows what happened after the instant time of trigger.

When the input signal is crossing the trigger level, which is to be adjusted by the user, a linear sweep signal is generated (Fig. 4.40).

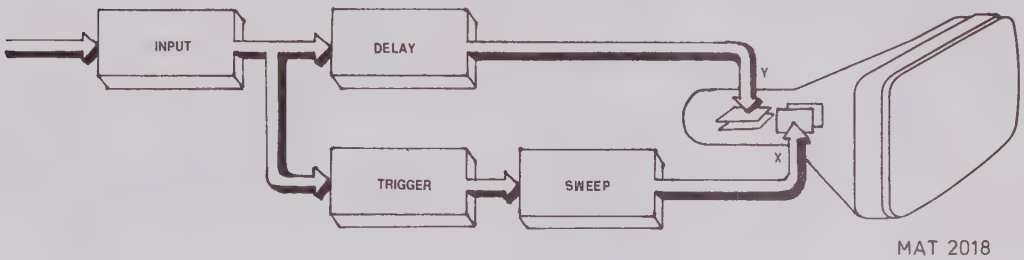

Fig. 4.40 Simplified schematic of analog scope

This sweep signal connected to the x-plates and a periodic input signal connected to the y-plates of a CRT gives an image displayed on the screen.

The input signal is to be delayed for a certain amount of time to display the signal at or before the trigger crossing point, e.g. for comfortably adjusting the trigger level (Fig. 4.41). The circuit is usually completed by line trigger circuits, extern trigger circuits, electronic switches for display of two input signal, delay circuits for display of signal sections etc.

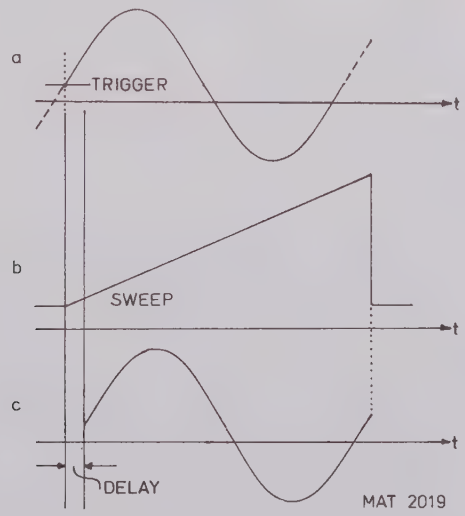

Fig. 4.41 Display of waveform with analog scope

a) Input signal
b) Sweep signal
c) Displayed waveform

A DIGITAL STORAGE SCOPE

A digital storage scope has a trigger circuit like every normal analog scope or analog storage scope, but time relation between trigger point and stored signal is by far more flexible because of the special construction.

The digital storage scope has an input buffer memory which is organized like a circular memory. This takes place by overwiting the oldest data by the data, most recently received from the ADC. Therefore in the memory there always exists an image of the recently recorded portion of the signal.

In digital scopes the trigger is used to stop the renewing of storin processes. Therefore the memory may hold information from the time before trigger occurred.

This is very useful, but nevertheless one often wishes to see information from the time after. This is realized by starting a presettable counter, a so called "delay counter" with the trigger signal. This counter counts for a selectable number of clock periods and then stops the recording. Now data is transfered to a video memory; permanently refreshing the image displayed on a CRT (Fig. 4.42).

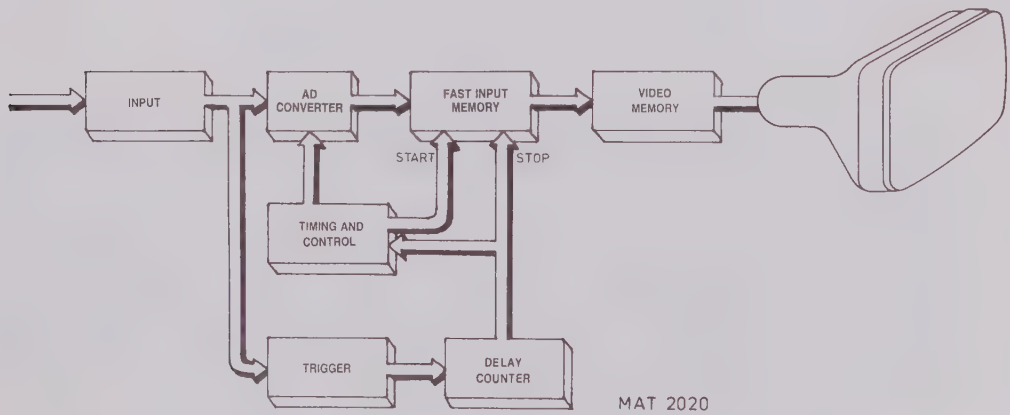

Fig. 4.42 Simplified schematic of digital scope

The number of clock periods defines which part of the signal is stored.

Fig. 4.43 shows the possibilities a digital storage oscilloscope offers. Setting the delay counter to 0 there is no clock periods delay and the display shows what happened before the trigger occured. This is called "full pretrigger" (Fig. 4.43a).

If recording takes place over a number of n clock periods, in fact n samples of the input signals are taken and stored in the input buffer memory, and if one selects a number of n/2 clocks for the delay counter then half the memory will be filled with information before and half the memory will be filled with information after trigger occured (Fig. 4.43b).

With a delay of n clock periods equal to the maximum recording depth the whole information is from what happened after trigger occurred (the normal case which is wellknown from analog scopes). This is what is called "full posttrigger" (Fig. 4.43c).

A special feature is offering the possibility to delay the recording process by more than the total number of memory cells. If we delay by a number of (k+n) clocks we are able to view the signal a long time after trigger occured, but consider that the trigger cross point is out of the recorded part of the signal by an amount of k clocks (Fig. 4.43d).

Every channel of the PM3360 includes a 16 bit delay counter and with its maximum recording depth of 4 k memory cells per channel one has a total possible delay of 16 times the maximum memory depth.

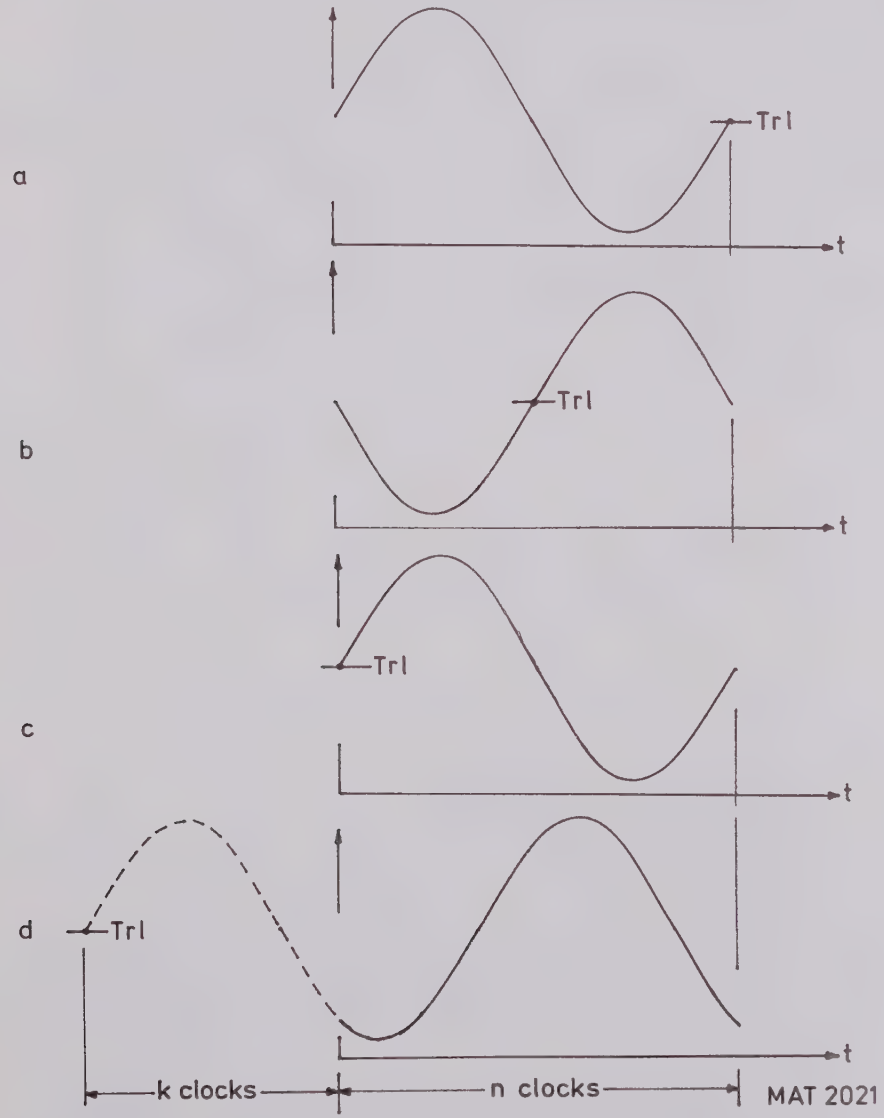

Fig. 4.43 Display of waveform with digital scopes

a) Delay of 0 clock periods - full pretrigger
b) Delay of n/2 clock periods - half pretrigger/half posttrigger
c) Delay of n clock periods - full posttrigger
d) Delay of n + k clocks - trigger out of display

The very important conclusion is, that working with a pretrigger is the only possibility to record that part of the signal, that has been responsible for triggering.

One can easily understand that with a digital storage scope it is possible to capture transient signals, or like with the PM3360, to work in e quasi real-time mode by displaying a signal and after a new trigger occurrred replacing the image by this new one etc. This leads to a repetitive recording, which is especially interesting with periodic waveforms.

A fixed time base as it is usually called in analog scopes is replaced by the sampling process in digital scopes.

The time between samples which are taken from the signal can be selected. Therefore the total "time base" is calculated by

(Sample time) x (number of memory cells)

Fig 4.44. shows an example of a recording of a transient signal. 64 samples are taken with a sample time of 10 us. The delay counter is set to 42 clocks. Therefore we have a "time base" of 640 us, 220 us pretrigger and 420 us posttrigger information.

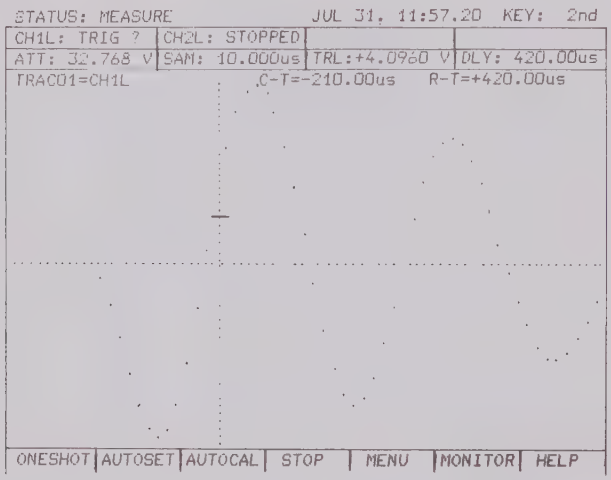

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Fig. 4.44 "Time base" calculation

tb	... "time base"	(C-T)+(R-T)
prt	... pretrigger	(C-T)
pot	... posttrigger	(R-T)
trl	... trigger level	(TRL)

With the PM3360 you are able to select the number of memory cells used up to a total number of 4 k. Sample time depends on what type of input module you use. The analog module PM3363 has a minumum sample time of 20 ns, respectively a sample rate of 50 Mio samples/second.

The sample rate can be continuously divided with a 16 bit sample counter. This leads to a choice of 65 536 different "time base" possibilities.As recording length can be selected freely up to the maximum of 4k words the actual time base is given by multiplication of the selected recording length and the sample time. Practice shows that for an analog-scope-like work a recording length of 512 will be satisfying.

4.8.2 Mainframe (see Fig. 4.45)

The mainframe includes the processing device as well as reference memory, video circuits, power regulators etc.
The PM3360 advanced multiprocessor system is a very powerful tool to the instrument´s user, but one is not burdened with the complex data transfer and calculating activities anyway. The system has been constructed to work in an ergonomically very advanced manner with respect to the men-machine interaction and is designed to fulfill future demands as well.

To be prepared for what future will claim a very modern multiprocessor system has been installed, which includes two 16-bit 8086 processors, one of them supported by an 8087 arithmetic coprocessor, an 8089 I/O processor as a fast data transfer link between all modules, the base unit as well as the input-and trigger manager modules and optional I/O devices like plotter, printer, IEEE - talker - listener interface etc. and a 2903 bit slice processor which performs all image transformation calculations.

All control-commands are given to the instrument by means of two keyboards. One of them is placed below the CRT-screen. Ther are keys for direct manipulations of certain parameters like sampling rate, attenuator etc. and seven softkeys. These softkeys are used for different actions and commands while working on different levels. They are relabeled accordingly by names, values etc. displayed on the screen immediately above them. This allows to provide complex features in a "self-explanatory" manner. Handling is as comfortable and versatile as possible. The other keyboard is a full ASCII-keyboard and is used for entering labels, values, names etc. and for programming the instrument.
Working with the PM 3360 is also supported by another special feature - a seven color display. This is not only attractive; it is also much easier to keep control over different waveforms, you make less mistakes in interpreting measurements and you need less concentration to do the same job as with a monocolor CRT.

When the instrument is in a normal recording mode, data flow can be described as follows:
An input signal is adapted to the A/D-converter´s range by means of the attenuation circuit. Conversion takes place permanently and data is filled into the fast input buffer memory. After a trigger signal has occured and delay time has passed, the recording is stopped and the whole block of data is transfered to the internal reference memory (main memory) by the 8089 I/O processor. The main processor (8086 + 8087) performs calculations on this data, e.g. computing frequency, RMS value and/or computing a set of new data by e.g. multiplying the incoming data of the channels etc. and then gives order to transfer data to the FIFO. The main processor will also give certain parameter values for display to the 8086 character processor, which will calculate actual characters for visual use. The data will now pass a 2903 bit slice processor, which performs fast trace processing, that means transformation of data to picture coordinates and shifting, zooming, etc. of the whole image, and will finally be transfered to the video memory. Characters and graphics are also transfered to the video memory from the 8086 character processor.

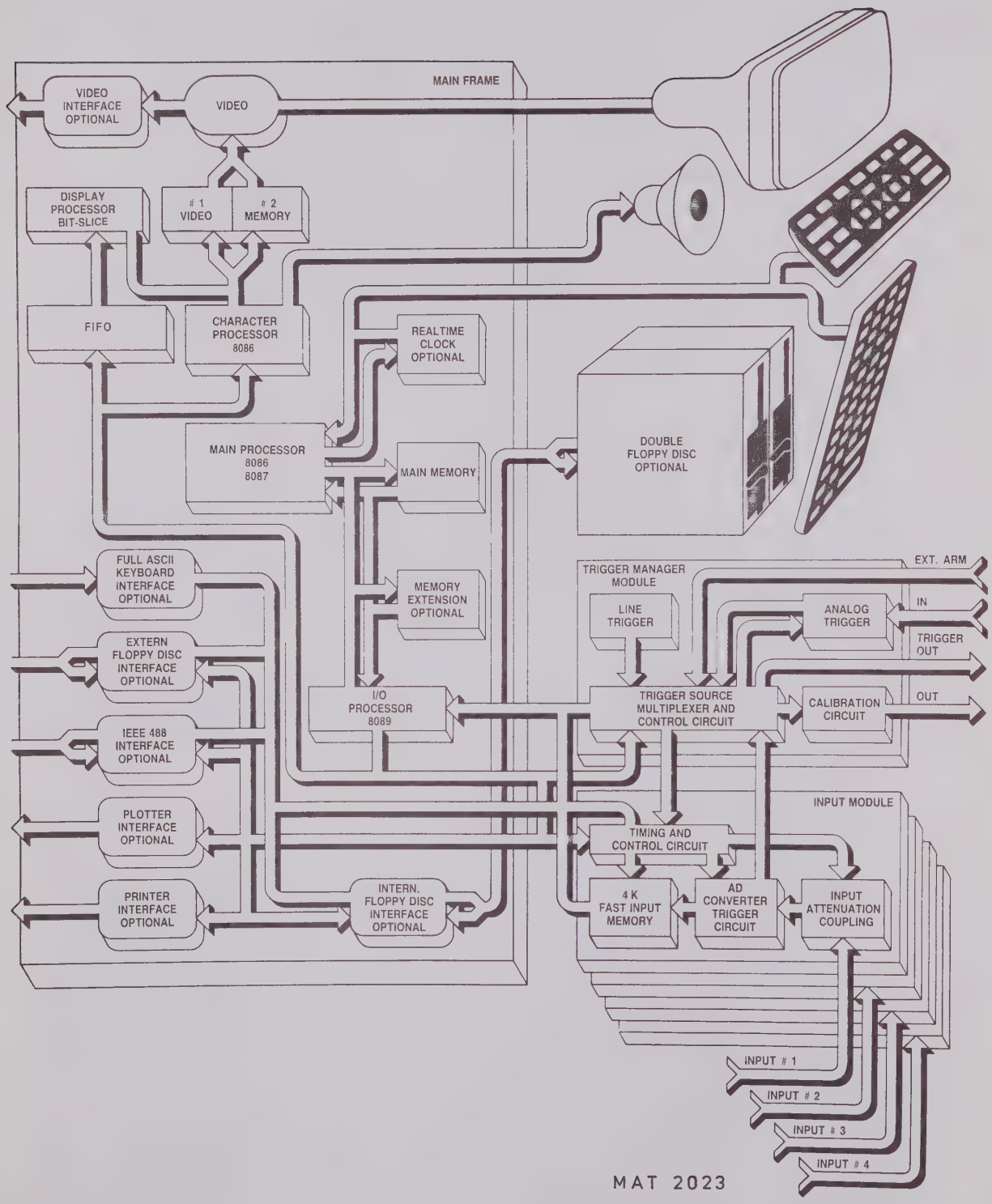


Fig 4.45 Blockdiagram of PM3360

The video memory consists of two halves, so that one half can be permanently read out to the video CRT for flicker free display, while in the other half a new picture is created.

Respecting this mechanism of data manipulation it is easy to understand that the up-date rate of images is not a constant, but depends on how many details are displayed on the screen.

The construction of the main frame is shown in Fig. 4.46. On the left part of the front side, there are the screen and keyboard #1 below it. Adjacent to the right side of the screen keyboard #2 is mounted. This part of the front can be opened, behind its optional floppy disc drives can be installed. Fully to the right there is space to plug in input-modules and the trigger manager. Modules are to be fastend with screws from below.

Inside the instrument the video module (CRT and video electronics) is placed, which is covered by a shield to avoid electromagnetic disturbances and for safety because of the high voltages used there.

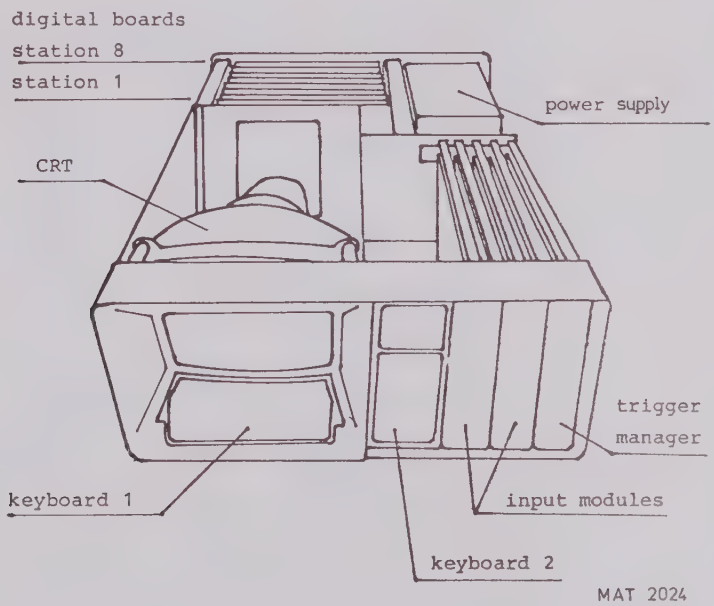


Fig. 4.46 Mainframe

Behind the video module the digital boards are placed. There are five boards in the base unit:

video memory	(Station no. 1)
bit slice processor	(Station no. 2)
FIFO-character processor	(Station no. 3)
I/O-processor	(Station no. 6)
Main-processor	(Station no. 7)

Optional boards are:

Interface-board (IEEE 488 interface, parallel and serial interfaces etc.)	(Station no. 4)
Floppy disc controller	(Station no. 5)
Memory expansion	(Station no. 8)

On the rear side of the instrument there is space for connectors for I/O devices. There are also a fan, the line connector and the fuse-holders.

The instrument is completed by the power pack, housed in a closed module.

All connectors between the functional units are mounted on bottom of the instrument.

Intensity and focus of the screen image can be adjusted individually by the user. On the left side of the frame, there are two openings. By inserting a screw driver, it is possible to adjust intensity and focus (Fig. 4.47).

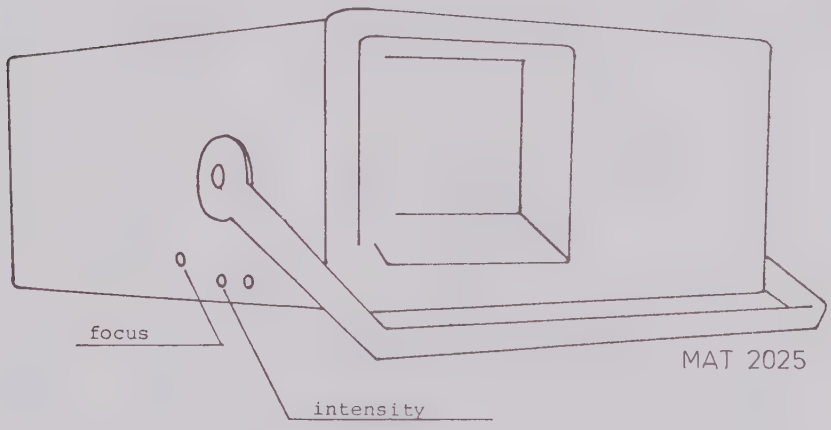


Fig. 4.47 Intensity and focus adjust

CAUTION: Use plastic screwdrivers and be careful not to damage potentiometers.

4.8.3 Input modules

Input modules are exchangable plug in units. This gives the advantage that there are no restrictions on you personal choice out of a selection of different types of input modules. You even can mix up types of input modules with various A/D conversion´s speed and resolution.

The following types of modules are available:

Name	Channel	Max. sampling rate	resolution
PM3361	dual channel	10 MHz	8 bits
PM3362	dual channel with differ-ent. inputs	1 MHz	12 bits
PM3363	single channel	50 MHz	8 bits

It is very important to consider that every channel is treated independently of the others irrespective of how the system is configurated. This feature is supported by the way of construction:

Every input channel contains its own coupling circuitry, attenuator, offset circuitry, A/D converter, fast buffer memory with corresponding memory address counter, sample counter, delay counter and trigger circuitry. All mentioned parameters can be set or adjusted individually for each channel (see Fig.4.48).

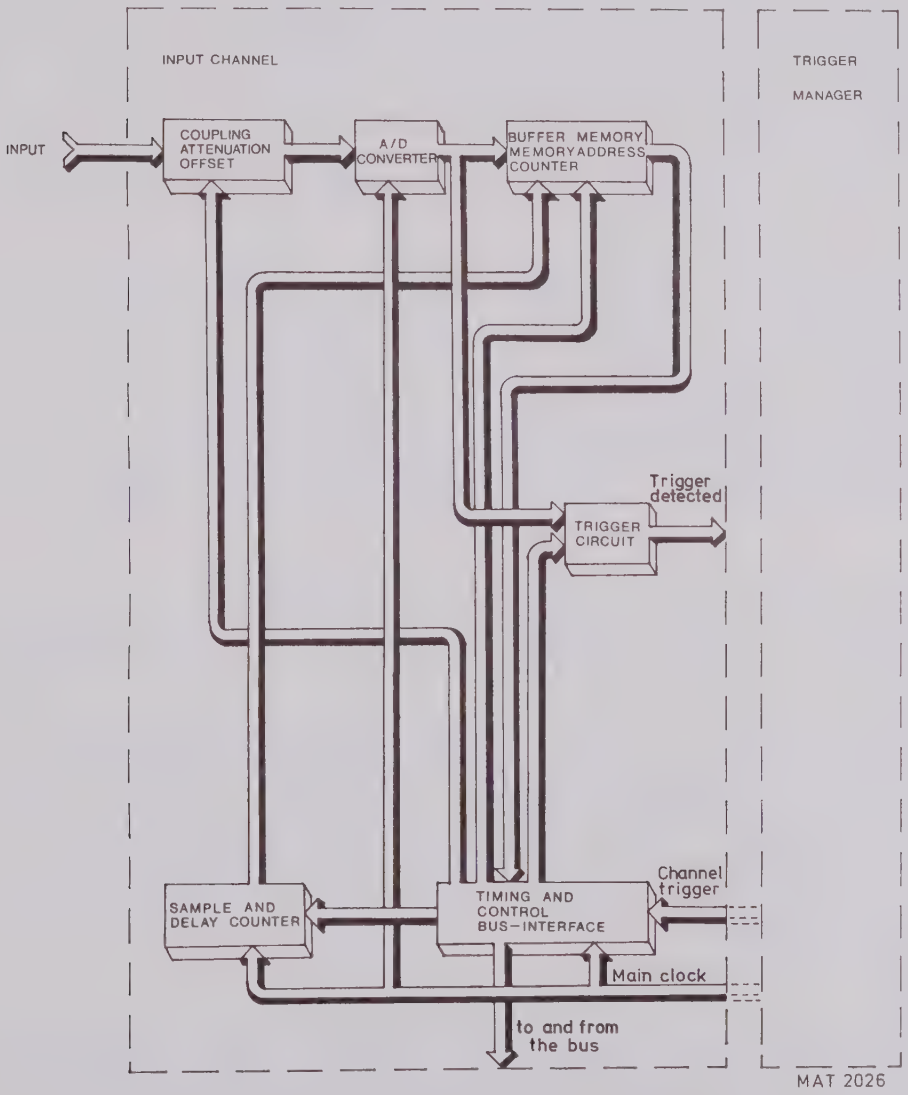


Fig. 4.48 Blockdiagram of input channel

The parameter values are transfered to or from the corresponding registers via the bus interface. Signal conditioning parameters are coupling, attenuation and offset voltage. Recording parameters are sample rate, delay, recording length and trigger level. The main clock for timing purposes is generated in the trigger manager module and fed to every input channel.

Recording procedure is performed as follows (compare section 4.8.6): After the main system has given the start command for recording, there is a necessary prerecording time that depends on the amount of pretrigger information and, of course, on the recording length selected. This preparatory state is indicated by the label RECORD in channel status field on screen. Of course, one will only be able to recognize this label at low sample rates.

From that instant the system is prepared for the recording process since buffer memory contains actual recording data and conversion and restoring of signal data continues. The system is enabled , which will be shown on channel status field by the label "ENAB"? if one works in the oneshot operation mode. In this case enabling has to be done manually and the system continues to the wait for trigger status which will be indicated by the label "TRIG?" in the channel status field. If the system has been set to the repeat operation mode the system continues automatically to the wait for trigger status "TRIG?". Indication is also performed in channel status line in the same way as in oneshot mode, but will only be visible at low sample rates.

If trigger has occurred according to the trigger condition (see section 4.8.4) which has been selected, the system continues to the delay status. The delay counter starts to count for the preselected number of clocks. This status is indicated by the label "DELAY" in channel status field but again can only be observed at low sampling rates. When delay counting has passed the recording process has been finished and data are to be read out for storing, display on screen etc. The system is in the wait for service state which is indicated by a label "DATARDY".

This label will be visible only if there is a lot of time necessary for readout (a lot of channels, a lot of traces, time consuming calculations, like Fast Fourier Transform etc.) or in case of serious system errors if the main system does not react to the service request.

The basic construction of an input module is easy to understand. It contains elements of usual analog and digital scopes, but there is one important difference to comparable systems. The trigger signal is detected in the input module by a digital trigger circuit, but this signal is not directly used for triggering. It is sent to a circuit names trigger manager for further processing. The actual signal for channel triggering is received from that unit in exchange.

4.8.3.1 Input Signal Conditioning

Conditioning of input signal includes the mode of signal coupling, the attenuation or amplification of analog signal and summing of a DC voltage to the signal. This allows to shift the mean value appropriatly, so that the dynamic range of the signal corresponds to the full range of the ADC-input.
This can be explained by a simple example: If one wants to observe a unipolar signal with DC-coupling there would e.g. only half of the input conversion range be used and only half of the optimal resolution. By adding a convenient offset voltage to that signal it is possible to shift it to the center of the A/D-converter´s range and to select a more sensitive input range for use of full converter resolution (Fig. 4.49).

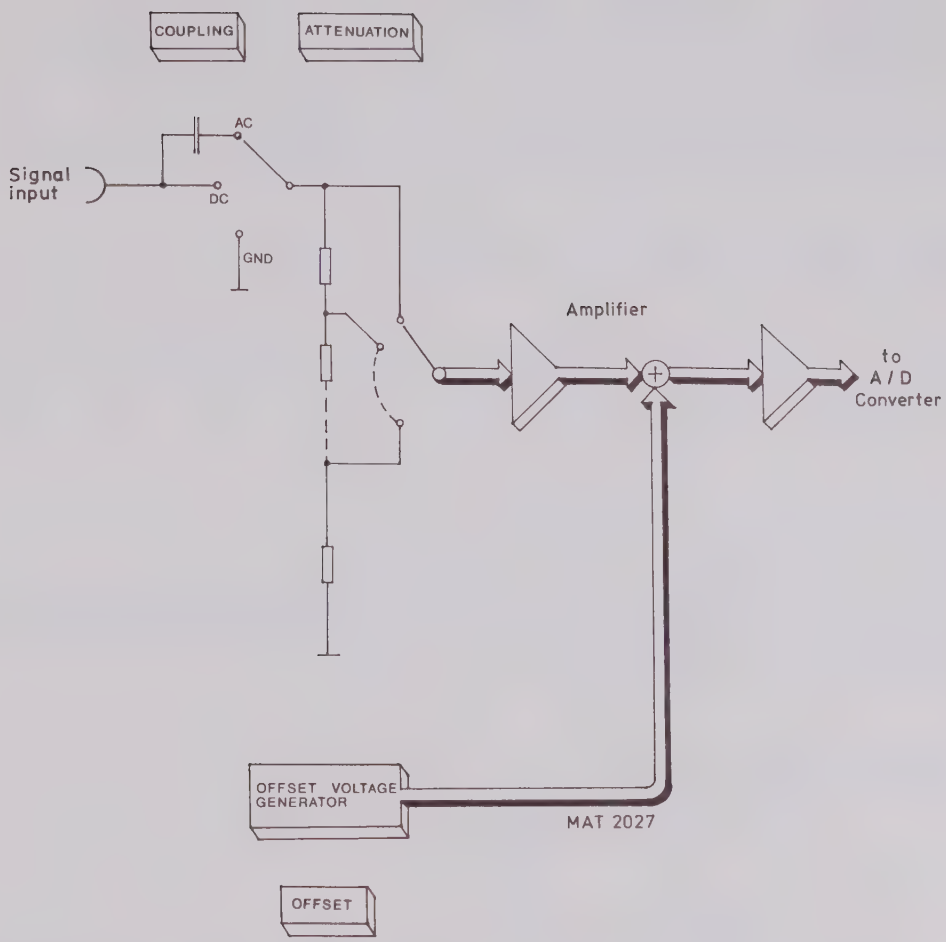


Fig. 4.49 Input conditioning circuit.

The coupling switch can be set to either AC-coupling, DC-coupling or to the ground level (GND).

The attenuator is constructed as an 11-range frequency compensated voltage divider. Input signals can be adapted to the full scale range of the A/D-converter by attenuation and amplification. For 8 bit converter types(PM3361, PM3363) there is a selection of 11 input ranges, every succeeding range with the full scale voltage doubled, starting with +/- 64 mV input range and going up to +/- 65,536 V. This gives a resolution of 500 uV per increment in the lowest range.

The 12 bit converter type (PM3362) offers 9 input ranges from +/- 512 mV up to +/- 65,536 V which gives a resolution of 125 uV per increment in the lowest range.

Offset is adjustable over the full positive or negative input range which has been selected.

Applying a certain offset voltage leads to the following:

a) Trigger level is held constant within the input range.
b) Displayed trigger level value is corrected automatically.
c) Amplitude calculations like e.g. maximum value, RMS etc. are corrected automatically.
d) Base line is shown in the position corresponding to the added offset voltage.

This means that the user does not have to take care on the selected offset voltage anyway.

The offset voltage generator has a resolution of 10 bits for 8 bit converter types (PM3361, PM3363) and 14 bits for 12 bit converter types (PM3362). The increased resolution is used for zero voltage calibration purposes.

4.8.3.2 A/D Converter and Buffer Memory

This part of and input channel includes the A/D-conversion circuit (with 8 or 12 bits resolution depending on type), a fast input buffer memory with 4 k memory cells and the corresponding buffer memory address counter (Fig. 4.50).

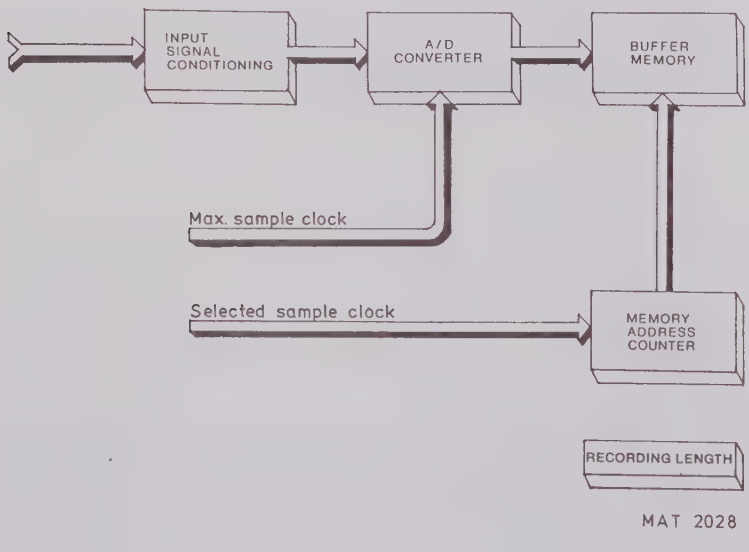


Fig. 4.50 A/D converter and buffer memory

The input signal conditioning adapts the input signal to the conversion range of the A/D converter. Conversion takes place with the maximum sampling rate depending on input type and storage of data is performed with a rate given by the sample clock.

The digital word is represented in two´s complement, which has to be considered to obtain the actual relations. If the attenuator is set to a full scale input range of e.g. 2,048 V symmetrically around zero, which would mean +/- 1,024 V, the actual converting range is given by (-1,024 V) to (+1,024 V - LSB).

LSB is called the value of the least significant bit describing the voltage difference between two digital values and is obtained by the quotient

Full scale / number of increments

The number of increments is given as 2^8=256 for 8 bit converters and 2^{12}=4096 for 12 bit converters respectively.

Therefore with a full scale range of e.g. 2,084 V we get an actual range of

-1,024 V to + 1,016 V

for 8 bit converters (see Fig. 4.51) and

-1,0240 V to + 1,0235 V

for 12 bit converter types.

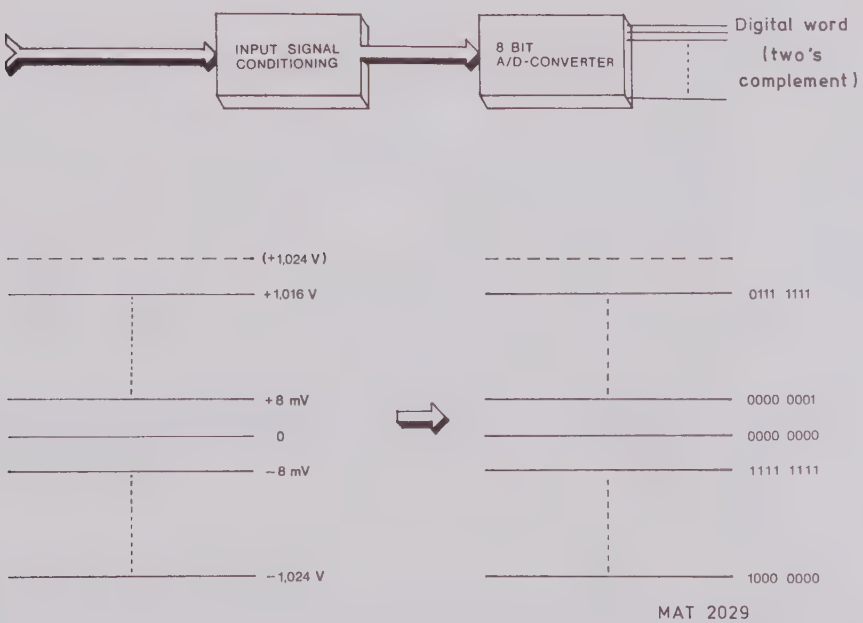


Fig. 4.51 Representation of the digital word in two´s complement (8-bit converter)

A limiting value for the memory address counter can be set, that leads to the possibility to select the recording length individually. Note that due to the internal trigger signal processing there is the necessity for delaying the incoming signal. This results in the loss of some of the data points in high speed buffer memory. Therefore a maximum of 4088 data points can be recorded instead of 4096.

Since the update rate of the display depends strongly on the number of points to be handled by the display transformation processor (Bitslice 2903) it is recommended to use smaller recording length while using the PM3360 as a quasi real time scope recording periodic waveforms.

4.8.3.3 Sample and Delay Counter

The recording sample rate and delay can be selected by the user in a wide range. The main clock, fed to the input channel out of the trigger manager, is divided by the sample counter. This divided signal, the "sample clock" is used by buffer memory address counter as well as by the delay counter. The delay counter is started by the trigger signal and after the selected delay time has passed it stops the recording (Fig. 4.52).

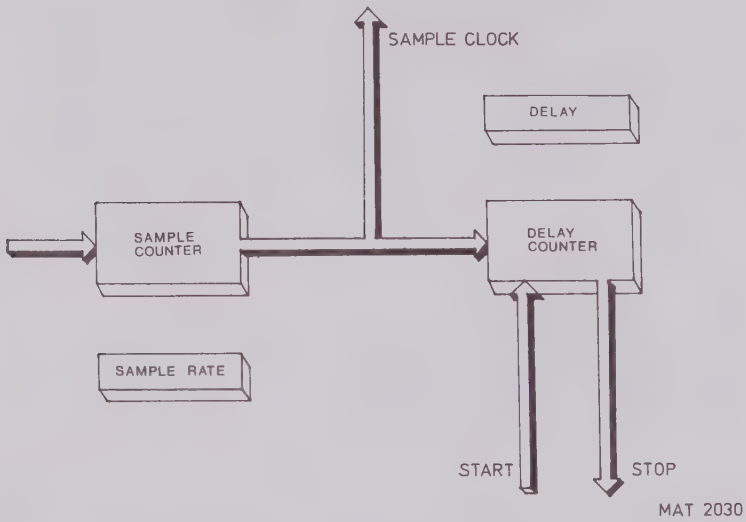


Fig. 4.52 Sample and delay counter

The main clock rate can be divided by the 16 bit sample counter by a free selectable factor of up to 65.536.

The 16 bit delay counter can be set to count a freely selectable number of up to 64k sample clocks. This means that by using the maximum recording length of 4 k points a delay of up to sixteen times the recording time is possible.

4.8.3.4 Trigger Circuit

As explained above, the PM3360 system is equipped with very flexible and versatile trigger possibilities. Every input channel can act as a trigger source using its own built in trigger circuit.

Triggering is performed by means of a digital trigger circuit. Digitized data out of the A/D converter are compared to the selected trigger level by an 8 or 12 bit digital comparator depending on the converter type. If the data word exceeds the defined trigger level (A>B) a "trigger detected" signal is generated and fed to the trigger manager module for processing. The signal for triggering the channel, called "channel trigger", is generated in the trigger manager, it depends on what trigger condition has been defined e.g. what trigger source has been selected (Fig. 4.53).

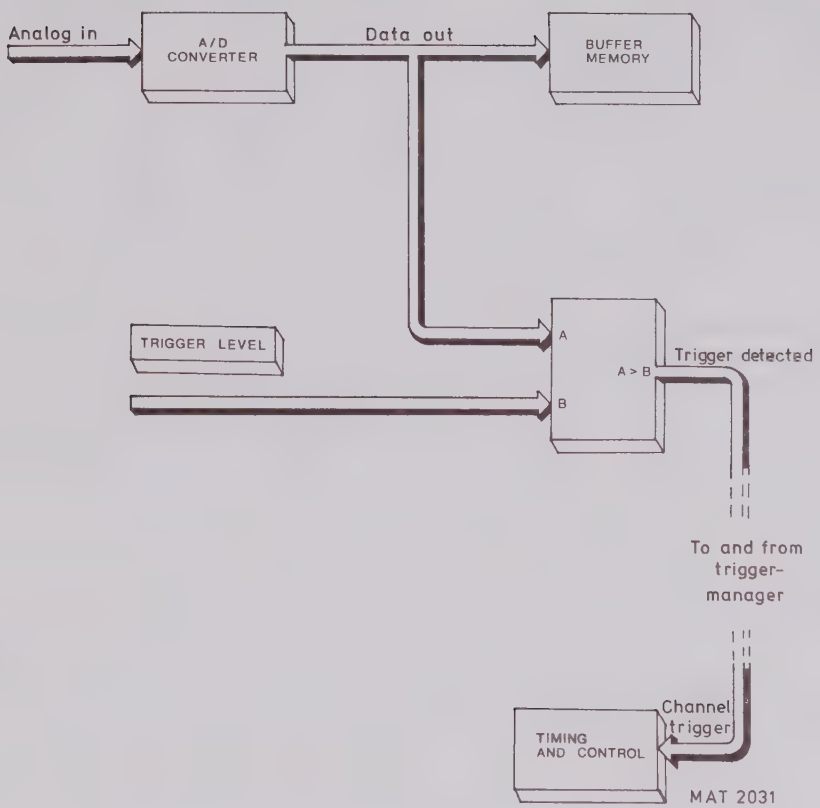


Fig. 4.53 Trigger circuit.

The trigger level can be adjusted in the same range and with the same resolution as the A/D-converter used. To avoid uncontrolable triggering because of signal noise, a hysteresis of 2LSB has been built in.

4.8

4.8.4 Trigger Manager

With the PM3360 absolutely new features for very comfortable and versatile triggering have been introduced. The usual way for defining trigger conditions is to select a certain trigger source, positive or negative slope and route this signal to the device (recording channel) to be triggered. The PM3360 system allows the processing of the trigger source signals in a way similar to that used on logic recorder. This feature offers a very flexible definition of trigger conditions by means of logic equations.

The triggering procedure can be described as follows:
Trigger sources feed the trigger signals (trigger detected) to the trigger manager, where these signals are processed in a way which is determined by the definition of the trigger condition. Outputs of the trigger manager are the actual trigger signal (channel trigger) which are used to stoop the resoring process in the input channels.

It is essential to mention that reasonable short time delays in the manipulation of the trigger signal are practically irrelevant in digital oscilloscopes because of the intermediate storage of the signal data in the input buffers.

As it will be explained below, every recording has to be enabled, which has to be done manually if the instrument works in the "one shot mode" or is performed automatically while working in "repeat mode" or "autoset-autocal mode". Therefore "enabling" can be described as setting the instrument to a state in which it is prepared to accept a trigger.

In addition, it is possible to control trigger signal flow by and external signal that is to be connected to the arm input. This control of the triggering provides very flexible operation when the PM3360 is part of a (programmable) measuring system. For easy handling this input is maskable, that means it can be enabled or disabled by the instruments user.

The trigger manager module contains the following parts:

A Processing Logic for computing actual trigger signals out of 8 trigger sources.

An External Trigger in circuit including trigger level voltage generator with two ranges of attenuation and AC/DC-coupling for the trigger signal.

A Line Trigger circuit for triggering on line dependent signals with triggering on the zero crossing of line voltage.

Two Soft Trigger registers which are to be set by the main processor calculated on e.g. real time events.

An External Arm in for hardware control of trigger signals: low level of TTL signals inhibits triggering, if the internal arming is enabled.

A Calibrator Circuit which offers a square wave output on an eyelet for frequency compensation on arithmetic correction of external probes or attenuators.

The trigger manager circuit is shown in Fig. 4.54.

The Main System Clock which is used for the clocking purposes of the input module group, which consists of up to four input channels and the trigger manager.

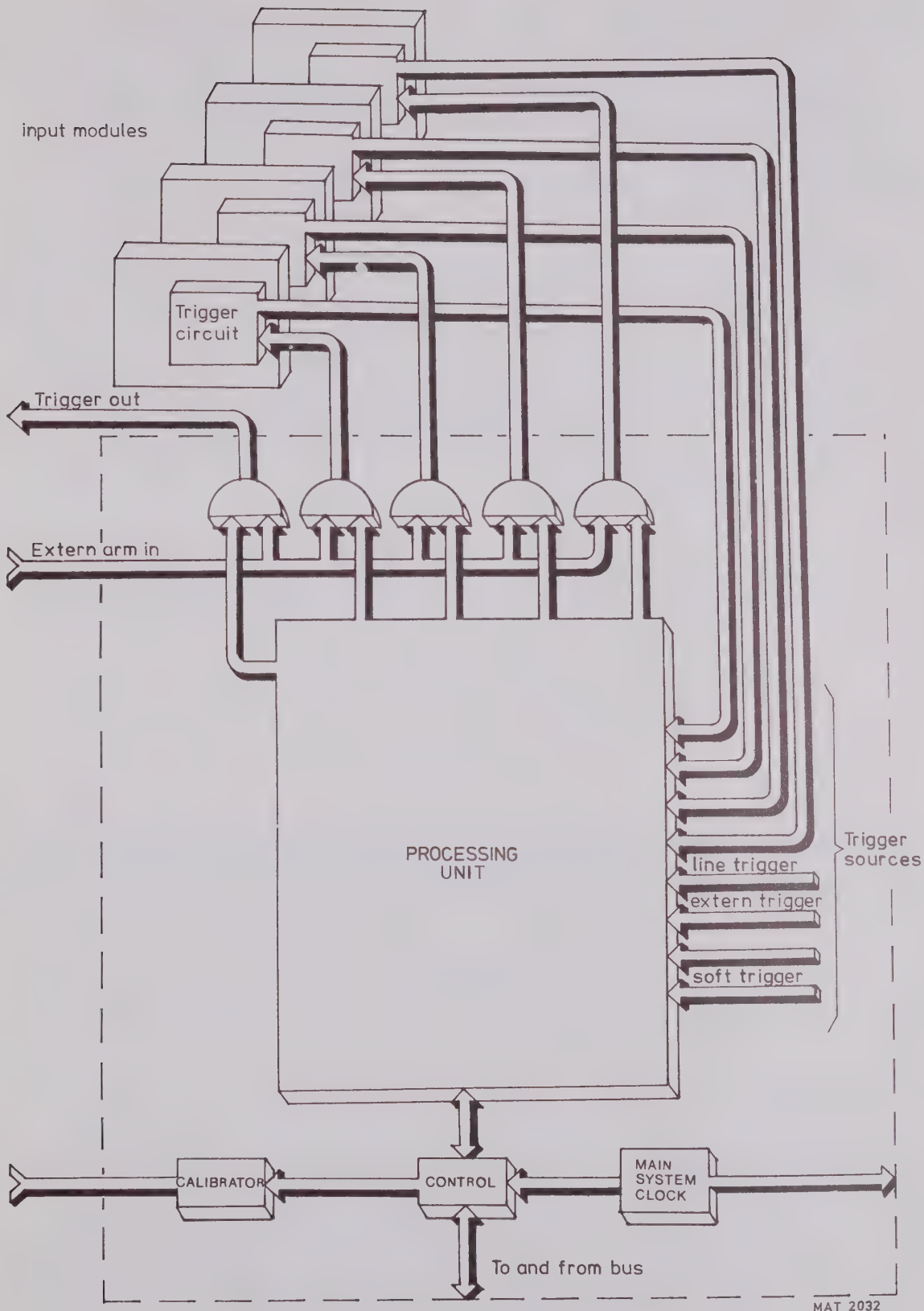


Fig. 4.54 Trigger Manager Scheme

4.8.4.1 Trigger Mechanism

The PM3360 method to process trigger signals offers and absolutly new and very flexible definition of trigger signals. Trigger signals are generated at the trigger sources at fixed or adjustable levels like in the line trigger, the channel triggers and the external triggers respectively.

There are up to eight trigger sources available: Up to 4 input channels, depending on the number of channels the PM3360 contains, a line trigger, and external trigger in and two definable softtriggers Trigger source signals are processed by a programmable logic circuit. This circuit is set to the necessary logic states depending on what trigger conditions has been defined in trigger menu (see 4.4.4). This logic circuit is called theanalog combinatoric trigger circuit. The processing is clocked by the main system clock, which is generated inside the trigger manager and which also serves as clock for the input channel timing. Incoming trigger source signals are synchronized to the system, processed and distributed to the trigger signal destinations which are, of course, the input channels selected for triggering (and a trigger out circuit). This signals are called trigger detected and channel trigger respectively.

An example for better explanation:
One wants to use a trigger condition where channel CH1L is to be triggered if zero level has been exceeded by the rising slope of the line trigger signal.

The trigger signal for channel CH1L has to be defined as

TR1L = LINE

which has to be done in trigger menu.

When having defined this condition the system will calculate the necessary logic states and program the processing unit according to this definition. Now the system is ready to accept and process trigger signals in the selected way which will lead to the following events.

When a line trigger signal occurs, it is synchronized to the system clock, recognized by the processing unit and fed to channel CH1L, where it will cause triggering, which means stop the renewing of storing process etc. as explained above.

4.8.4.2 Trigger Sources

The following (up to eight) trigger sources are available in an PM3360 system:

Depending on how the system is equipped up to four Input Channel Triggers may be available. Since there are modules including one or two input channels and the system is able to include two modules, the total number of input channels can range from one to four. The main system will automatically recognize number and type of the input (see section 4.8.3.4).

The trigger level is to be adjusted inside each channel. If the level has been exceeded by the input signal a trigger signal is detected and fed to the trigger manager.

The External Trigger in is installed inside the trigger manager. It contains an attenuator providing two ranges selectable as +/-4,096V and +/-65,635V, and an adjustabel external trigger level voltage generator which allows the adjustment of the external trigger level. The resolution is 8 bit in both ranges, AC/DC coupling can be selected (see section 4.8.4.5).

The Line Trigger receives the 50/60Hz line signal from mains via coupling device, performs appropriate filtering on the mentioned frequency and detects the zero crossing of line signal (see section 4.8.4.5).

Two Soft Triggers may be programmed and set by the main system. Conditions for setting can be either a certain time condition like "time limit exceeded", "time band entered" etc. or on an absolute trigger given under program control.

4.8.4.3 Analog Combinatoric Trigger

The versatile and flexible analog combinatoric trigger first introduced with the PM3360 system is a powerful tool in the instrument´s users hand, but, of course, it is necessarry to understand and become familiar with its possibilities.

Trigger conditions are defined by means of logic equations. The following logic operators are to be used:

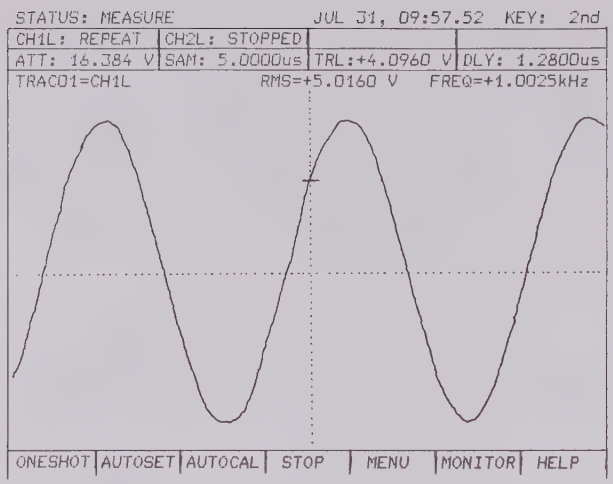
$\neg$ = NOT
$\wedge$ = AND
$\vee$ = OR

The slope on which the trigger level should be detected is defined by using the true or false denotation. True means trigger should take place on the rising slope of the signal, false means trigger should take place on the falling slope of the signal. This has to be defined e.g. in the following way:

rising slope - true - TR1L = CH1L - TR1L = CH1L
falling slope - false - TR1L = NOT CH1L - TR1L = $\neg$CH1L

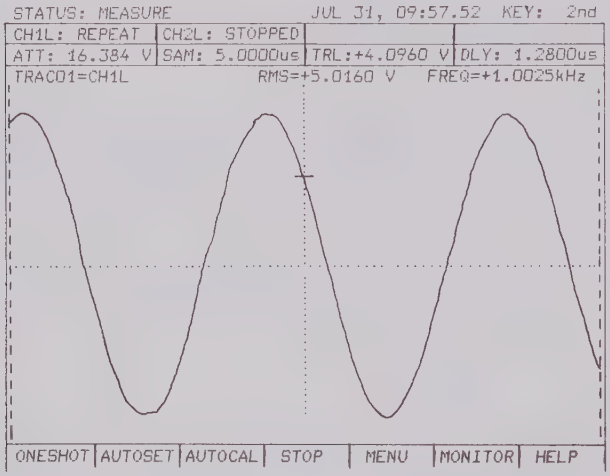
The effect of triggering on rising or falling slope is to be seen in Fig. 4.55 and Fig. 4.56 respectively.

This way of selecting rising/falling slope leads to absolutely new possibilities. Including of logic operators like AND ($\wedge$) and OR ($\vee$) offer the possibility to define almost every possible combination of enabling, defining absolute or conditional trigger etc. for two or more trigger signals. The effect of an AND combination of two trigger signals is shown in Fig. 4.57.



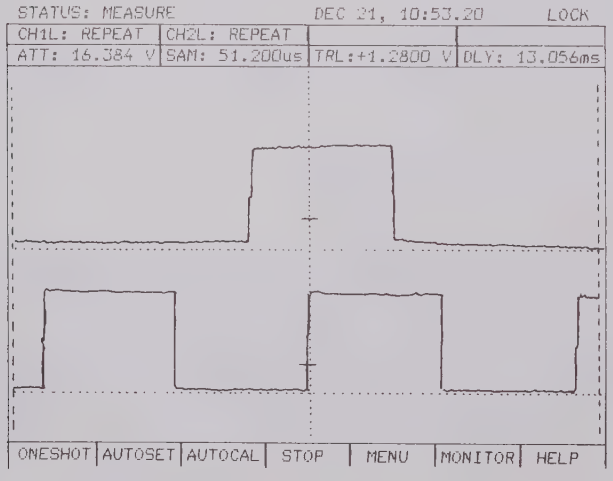
MAT 2033

Fig. 4.55 Trigger on rising slope TR1L = CH1L



MAT 2034

Fig. 4.56 Trigger on falling slope TR1L = ¬CH1L



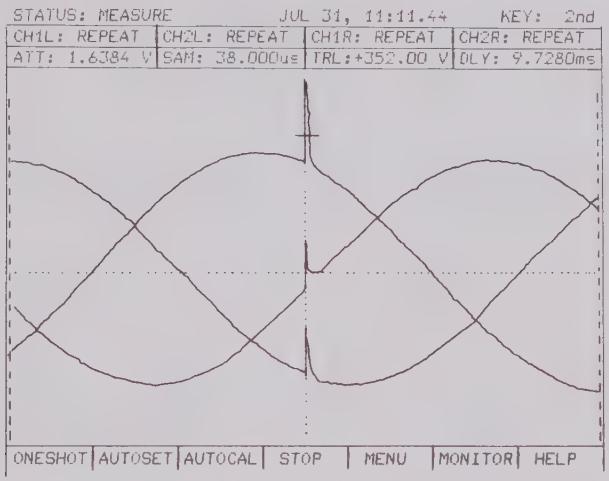
MAT 2035

Fig. 4.57 Trigger AND combination
TR1L=TR2L= CH1L ∧ CH2L

Triggering can only take place when both triggers are in the logic high state, which offers the possibility to enable one trigger signal by the other.

The example shows two logic circuit signals. The signal CH2L has to be considered at that point of time, when signal CH1L is in a high state
(Note, that triggering takes place either at the rising slope of signal CH2L is in a high state or at the rising slope of CH1L if CH2L is in a high state).

If one defines an OR combinations of two or more trigger signals, each of them will trigger independent of the others (Fig. 4.58).



MAT 2036

Fig. 4.58 Trigger OR combination
TR1L=TR2L=TR3L=CH1L V CH2L V CH3L

Having formed this OR combination, one gets an absolute trigger on all three channels from either the TR1L, TR2L or TR3L signal. The above exapmle shows a 3 phase line voltage measurement, where it is from interest to record all three phases, if one of them exceeds the given trigger level because of e.g. a spike occurring on one of them. The purpose is that the user is able to study reactions of this disturbance on the other phases.

In addition, the PM3360 offers the possibility to define also a more complex logic equation and this will enable the user to find almost every "hidden" disturbance in his circuitry under test.

4.8.4.4 External Trigger Input

The Extern Trigger In circuit is to be used to trigger to recording from external signals which are not available in the instrument. For a more flexible use this circuit has also been established with an AC/DC coupling and a attenuation circuit with two ranges. These ranges are to be defined in the same way as the input ranges which means symmetrically to ground level.

A trigger level generator completes the circuit. As again digital word is represented in two´s complement and is given with 8 bit resolution, the adjustable range is

Range	Actual Range	Adjustable Trigger Level
8,192V	+/-4,096V	-4,096 to +4,064V
131,072V	+/-65,635V	-65,635 to +65,123V

A simplified schematic of Extern Trigger in circuit is to be seen in Fig. 4.59.

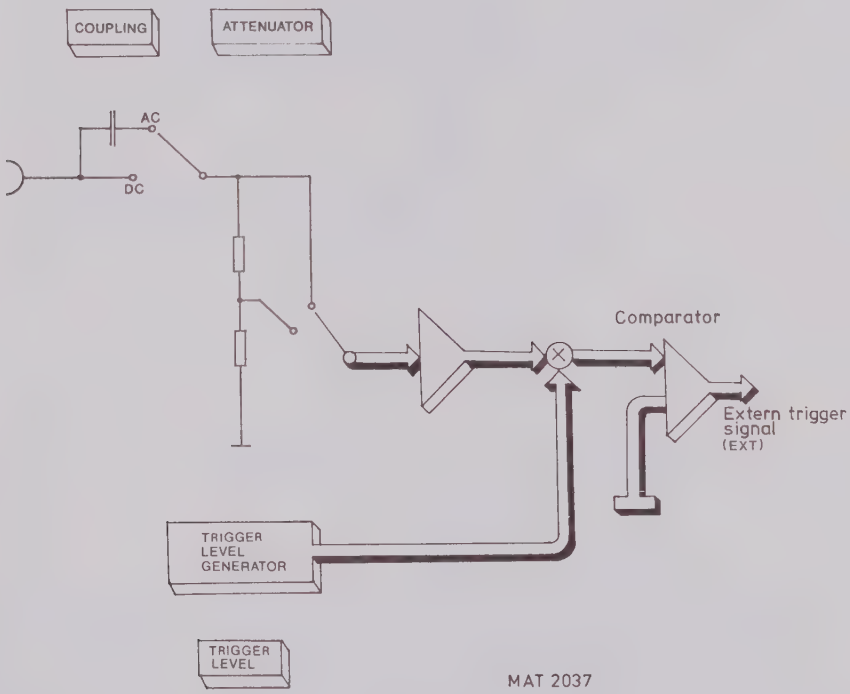


Fig. 4.59 Extern Trigger in circuit scheme

4.8.4.5 Line Trigger

The line trigger signal is derived from the primary line signal via opto coupler and filtered by a narrow band filter which is adjustable for 50Hz or 60Hz center frequency. The zero crossing is detected by a comparator.

4.8.4.6 Soft Trigger

Two free definable Softtriggers are another unique feature to the PM3360 system.

They can be used to perform e.g. absolute trigger or enable/disable trigger-sources either program controlled or time dependent, derived from the built-in real time clock.

4.8.4.7 Trigger Output - Extern Arm Input

PM3360 trigger manager features are completed by a Trigger Out and an Arm In possibility.

Trigger out is the same sort of signal as a channel trigger to one of the up to four input channels, but fed to an output jack, which offers the chance to trigger external circuits like experimental environments or initializing measurements etc.

External Arm input can be used for masking trigger signal by external signals. It is constructed as a synchronized AND-gating of the channel trigger signals with the External Arm signal (Fig. 4.60).

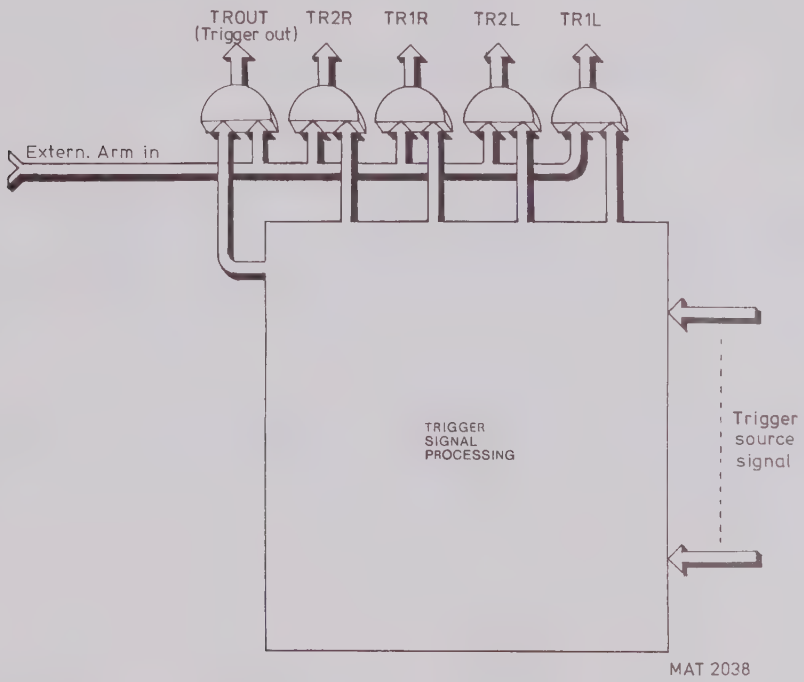


Fig. 4.60 External arming

Both trigger out and extern arm in are constructed with TTL levels.

4.8.4.8 Calibrator Output

Trigger manager´s equipment is completed by a calibrator out circuit feeding its signals to an eyelet on the front side for easy hooking up an oscilloscope probe. Calibrator signal parameters can be programmed in SET mode (see later) to either DC or 1KHz square wave. Level of this signal can be programmed to eight different voltages as

0V	0,1V	0,2V	0,4V	0,8V	1,6V	3,2V	6,4V

Square waves are to be used for frequency compensation of attenuation probes, a usual and well known procedure contained in almost every analog or digital scope (Fig. 4.61).

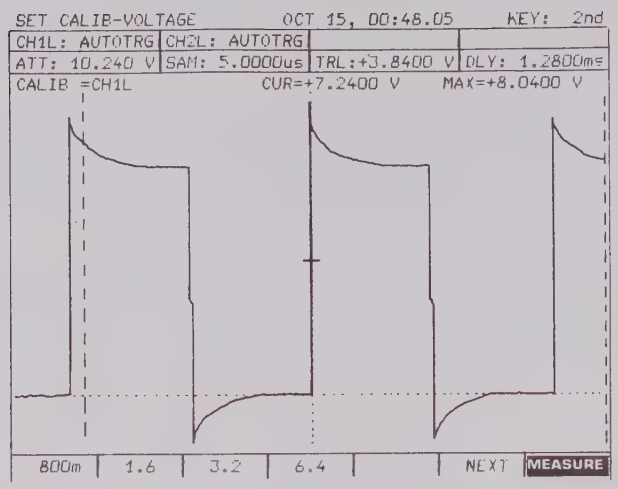


Fig.4.61 Calibrator out waveform connected to uncompensated 10:1 probe

To achieve a better utilization of input channels resolution the square wave can be set to the levels mentioned above. The picture shows a good example how built in measurement function (see DISPLAY menu) can be used for compensation. A very simple job is to adjust the peak to peak voltage of the square wave to 6,4V, the level which has been selected. Note that the signal has been DC-coupled and an offset of -3/4 has been selected.

Programming level to DC offers the possibility for making exact measurements on non standard probes or attenuators for getting attenuation values which can be corrected to instruments input channel ranges in INPUT menu (see later).

4.8.5 Waveform Recording

4.8.5.1 Recording Modes

The PM3360 offers various ways to record or freeze either transients or periodic waveforms. Because of the modern and versatile softkey concept it is very easy for the user to become familiar with the various modes of operation.

In principle one can distinguish between recording of periodic or transient signals.

For recording and analyzing periodic signals the PM3360 system offers the following recording modes:

a) The automatic trigger mode (AUTOTRG) which is wellknown from analog scopes. If a trigger is recognized, a recording takes place. If there is none after a certain time (depending on number of channels, calculated traces etc.) and absolute trigger will be given anyway. Therefore observation of DC-signals is possible with this mode of operation (see Fig. 4.62a).

b) The repetitive recording mode (REPEAT) works as AUTOTRG except the instrument waits until a trigger occurs, therefore DC-signals can hardly be recognized (see Fig. 4.62b).

When working with AUTOTRG or REPEAT mode one has to consider that because of the digitizing and storing process there is no immediate transfer, therefore the whole operation is what one calls "quasi real time operation"

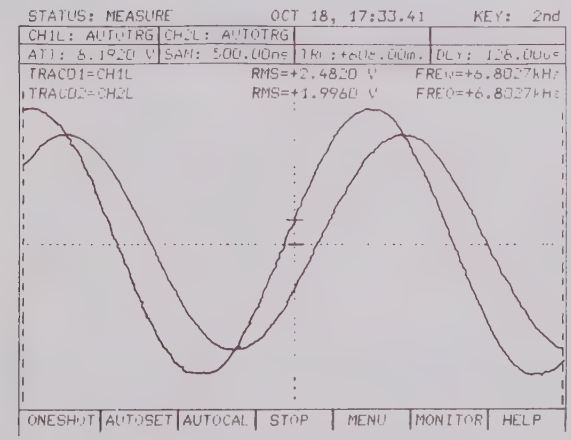
c) Recording can be stopped by pressing STOP-key (see Fig. 4.62c)

If the sampling rate and attenuation do not have appropriate values to get a clear display, the PM3360 is able to look for a periodic signal at the input in AUTOSET-mode.

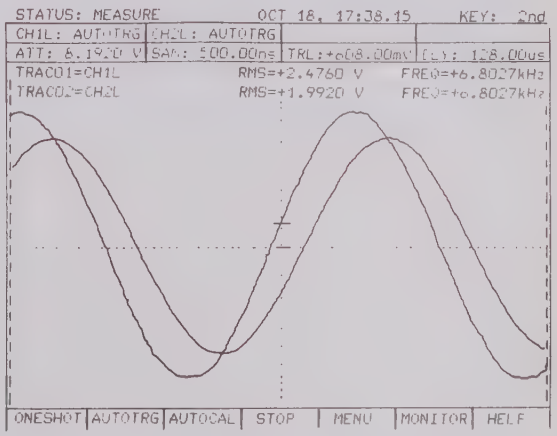
In AUTOSET-mode the instrument will automatically select an appropriate setting of attenuation and sampling rate for quickly and easily getting an image of the input signal. Coupling is set to AC and Trigger Level is set to 0 volts. Be aware the AUTOSET will not work properly at very low frequency signals because of signal noise and at very high frequency signals because of input amplifier overdrive.

After autosetting is successfully finished or not possible, the instrument returns to the REPEAT mode.

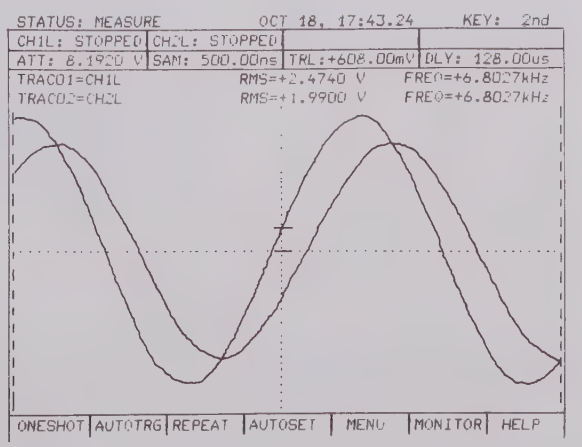
You will also find a softkey labelled AUTOCAL. Pressing this key leads to an automatic zeroing of the input channel. For high accuracy measurements, this should always be done before every high accuracy measurements.



a)



b)



c)

MAT 2040

Fig. 4.62 Recording of Periodic Signals

For catching of freezing transients, there are the following possibilities:

a) In ONE SHOT mode, the instrument asks for enabling in status line like ENAB? (see Fig. 4.63a). Pressing the Enable key leads to an enabling for recording activities, therefore the instrument asks for trigger by inserting TRIG? in status line (see Fig. 4.63b).

   If a trigger occurs, recording will take place and the instrument returns to the wait for enable (ENAB?) and has to be activated manually by pressing the ENABLE softkey again.

   In addition, it is possible to press the TRIGGER softkey, which leads to an immediate recording regardless of a trigger event or not.

b) REPEAT mode differs from ONE SHOT mode as enabling is performed automatically and it is not necessary to perform this manually. Therefore this is a very comfortabel way to observe incoming transient signals. If there is no trigger on ask for trigger (TRIG?) will be inserted in status line (see Fig. 4.63c).

c) A stop of further recording is possible in the same way as with recording periodic signals.

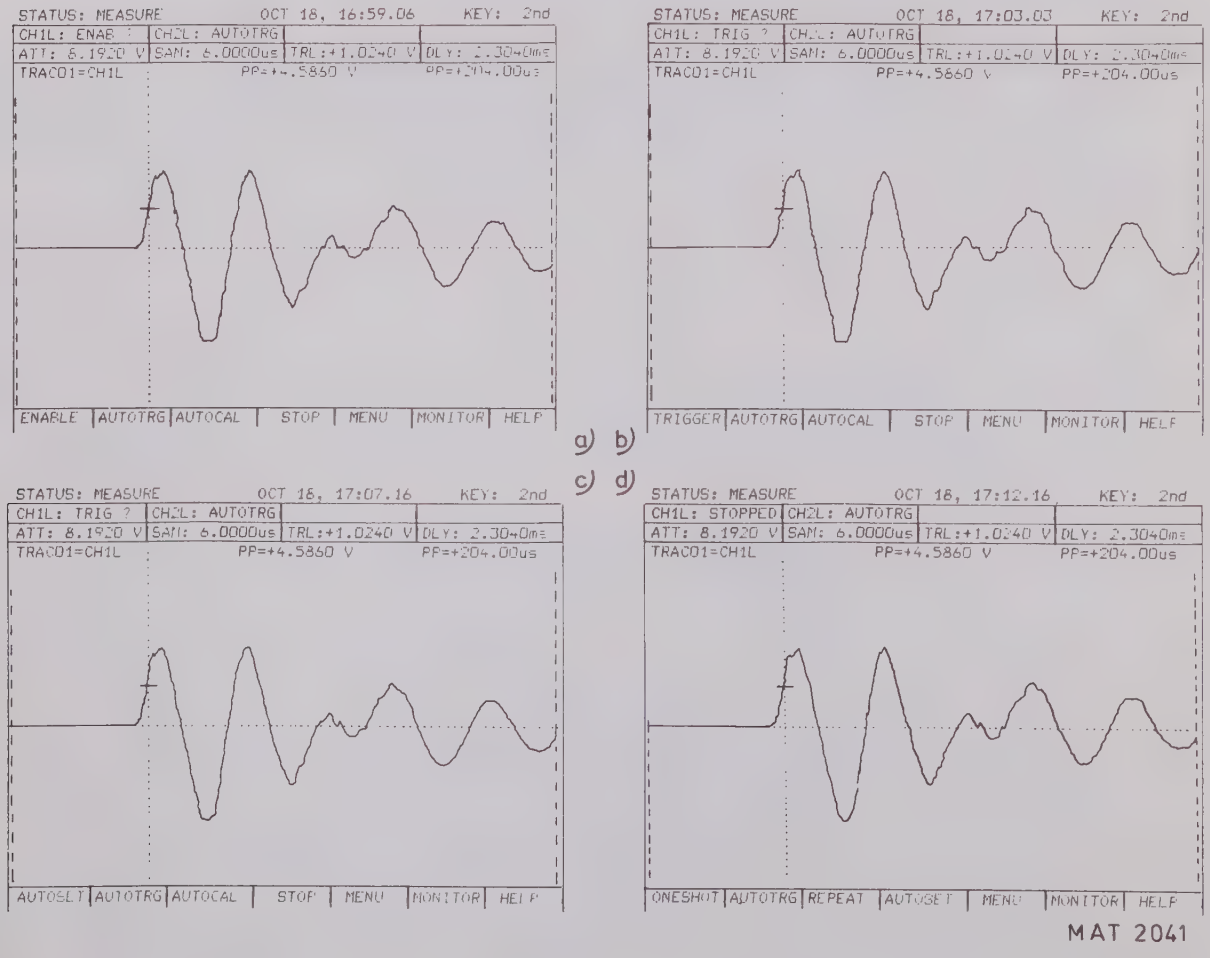


Fig. 4.63 Recording of transient signals

For working with the PM3360 system in a more "analog oscilloscope" like way it is possible to LINK parameters.

This leads to the following: changing of a specified parameter in any mode of operation is performed on all channels or traces simultaneously.
As and example it is possible to change the sample rate on all 4 channels by using the sample rate key rather than select channel CH1L, change sample rate, select channel CH2L, change sample rate etc. This leads to a way of operation like with normal analog oscilloscopes.

Linked parameters can also be unlinked for adjusting channels or traces independently.

For LINK and UNLINK procedure refer to Input Menu (section 4.4.2) and Trace Menu (section 4.4.3).

4.8.5.2 Alias Effects

The instrument uses a sampling system to examine the incoming waveform. Any such system an give misleading results known as alias effects if the input signal has a significant component with a frequency approaching or above the sampling frequency.

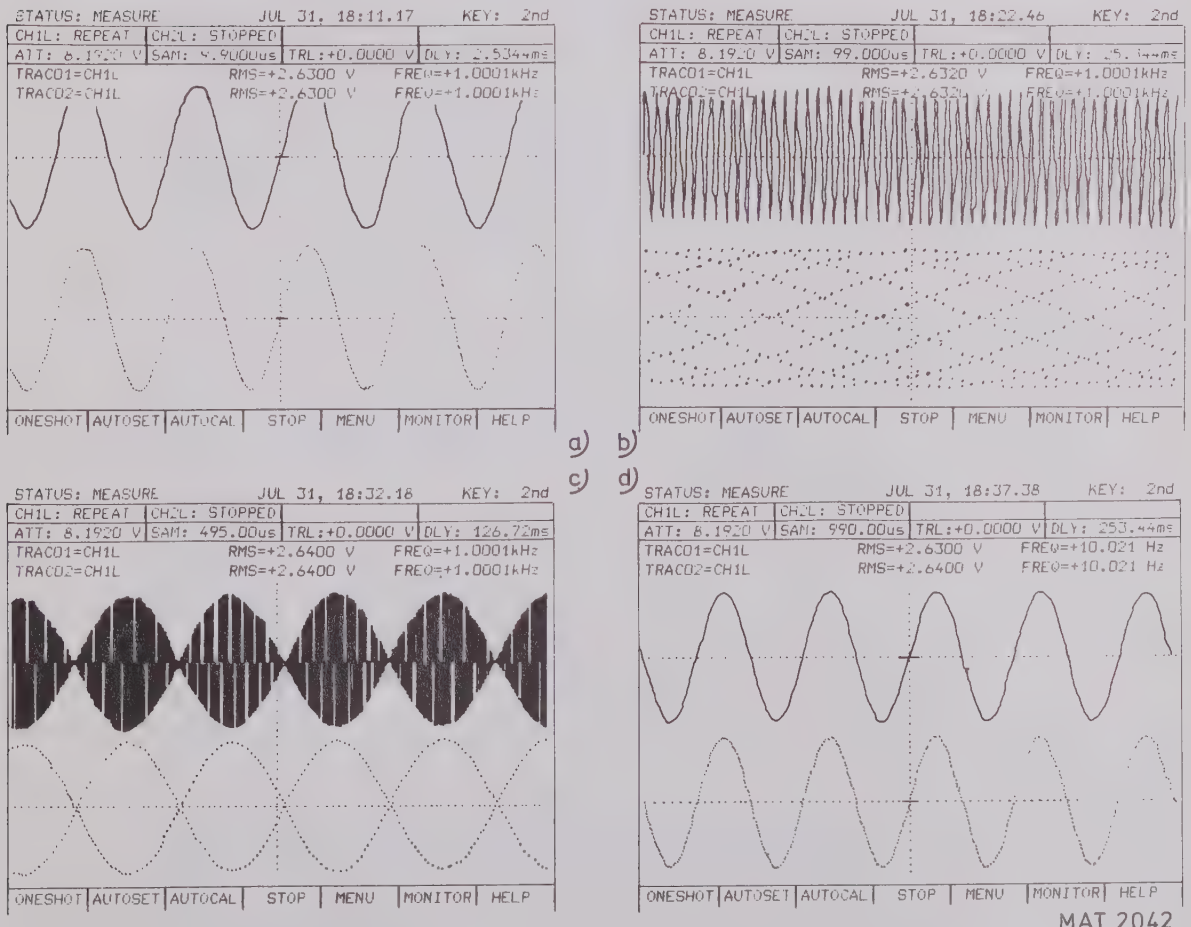


Fig. 4.64 Alias Effects

Fig. 4.64 shows the effect of sampling a given waveform at various sampling rates.
a) shows a waveform sampled close to 100 times the signal frequency.
b) shows the same waveform sampled close to ten times the signal frequency - if interpolation is switched off the displayed points show a meaningless image.
c) waveform sampled with near to twice per period shows some kind of modulated signal, but signal frequency and root mean square measurement are still convenient.
d) shows the waveform sampled close to the signal frequency itself - therefore "shannon theorem" is no longer met - calculated frequency is completely wrong.

4.8.6 Display of Waveforms

Section 4.8.1 informed about the advantages using a digital storage scope. Now you get a closer look to the capabilities of the PM3360. When working with this instrument you only have to keep one special feature in mind. The philosophy is that the PM3360 distinguishes between traces and channels.

A trace is a waveform you can see on the screen. It can be a recently measured, a calculated, a synthesized or stored and recalled waveform.

Channels are parts of the hardware. In these channels there are attenuators, amplifiers, A/D converters and fast input buffer memories.

A signal that is recorded or captured will be digitized and data will be stored in the buffer memory. This takes place in a specific channel. You have got an image of this signal in the buffer memory. Now the signal can be directly transferred to the screen for visual measurements. The reference is here a specific trace.

The trace you can see now on screen is corresponding to a signal that has been coming from the "real world".

In addition, PM3360 offers the possibility to define the following arithmetic calculations on waveforms: addition, subtraction, multiplication and division of two or more waveforms. The calculated data can be assigned to a new trace.

Third: waveform data which have been stored to a mass storage like reference memory, non volatile memory (optional) or Floppy disk (optional), can be recalled and assigned to a trace. These waveform data could be of a measured or a synthesized waveform.

Last but not least the user has the possibility to define assignment of data to trace in amplitude/time (Y/t) or amplitude/amplitude (X/Y) representation.

The origin defines where from a trace is coming. The origin of a trace can be selected in the (General) Menu (see section 4.4.1).

Overall, keep in mind once more: The trace on the screen can be made of a recorded or a calculated or a stored and recalled signal. The recording takes place in a (input) channel, the displayed information may be called from a buffer memory or from a mass storage directly or after having been processed (Fig. 4.65).

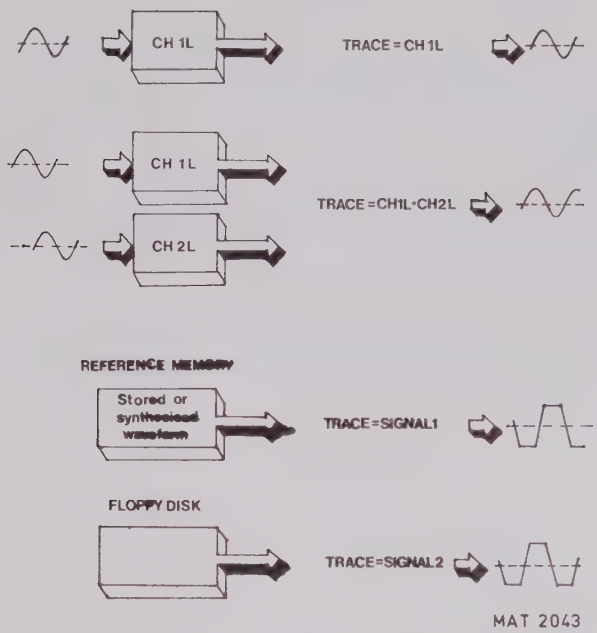


Fig. 4.65 Examples for assigning data to a trace

4.8.6.1 Amplitude/Time Representation

The most simple example of assignment is shown in Fig. 4.66. Two traces have been defined with the origin CH1L (channel one left) but this shows a very useful feature. One can observe a recorded trace overall (a trace named SHOCK) and expanded in both directions (trace named detail). As the origin consists only of one operand, a Y/t-representation is automatically taken into account.

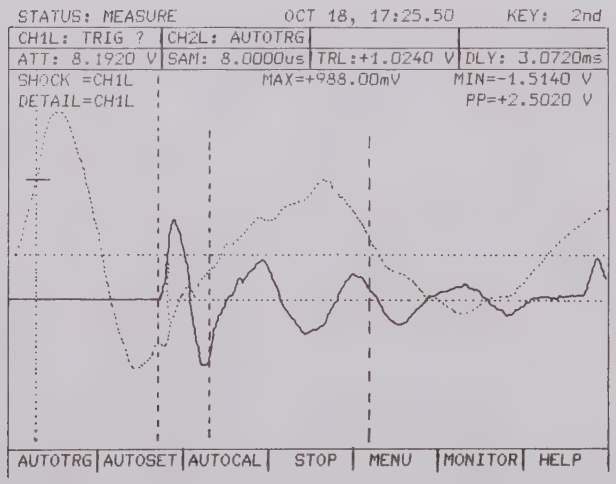


Fig. 4.66 Whole Recording and Detail

An absolutely unique feature of the PM3360 system is shown in Fig. 4.67. The traces named VOLT, CURR and POWR have been defined coming from origins CH1L, CH2L (channel 1 left and channel 2 left) and CH1L*CH2L (channel 1 left multiplied by channel 2 left) accordingly.

The PM3360 offers the possibility to define almost any algebraic function to be calculated on either channels or traces. In the exaple above it would also have been possible to write

POWR=VOLT*CURR

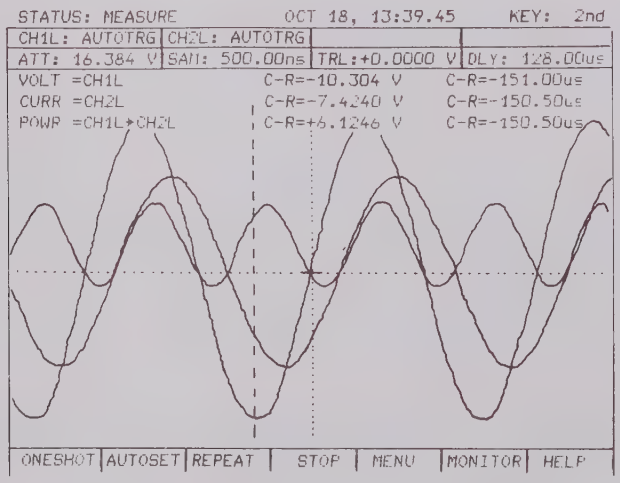
Therefore it is possible to perform the following calculations:

Addition
Subtraction
Multiplication
Division
Chaining of the above operation
including use of paranthesis)

This can be done at run-time or out of stored waveforms. There are no restrictions how to define a origin.

As it is possible with the PM3360 system freely to select recording length, delay etc. the system performs calculations as following. The trigger lines are connected and the overlapping data addresses are used for calculations.
Therefore it is possible that calculated traces have a lower number of "recording length" (=points per trace) than the "elements" used for calculation.

In addition, it has to be considered that the result of a calculation is normalized to the possible free screen space, so e.g. a multiplied waveform looks much smaller than the elements, but amplitude-measurements (see section 4.4.5) are displayed correctly (see Fig. 4.67).



MAT 2045

Fig. 4.67 Multiplication of traces

4.8.6.2 Amplitude/Amplitude Representation

Following the above it is very simple to understand the definition concept of the way how to define X/Y-representation. One has only to input the origin for the Y-direction and the origin for the X-direction separated by a colon and will immediately get the appropriate X/Y-image (see Fig. 4.68).
It has to be considered that the two recordings are connected together on the trigger line and if there are different recording lenghts and/or delays the overlapping data points are displayed.

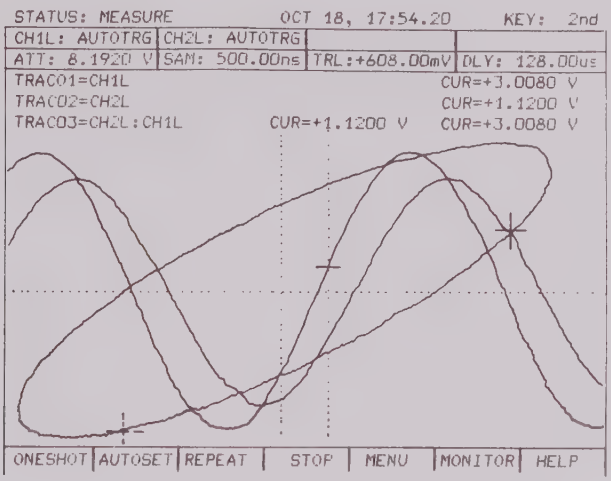


Fig. 4.68 Amplitude/Amplitude representation

Fig. 4.68 shows two traces TRAC01 and TRAC02 which have origins CH1L and a trace TRAC03 showing these two displayed in X/Y-direction. Cursor and Reference Cursor are inserted as crosses in this trace.

4.8.6.3 Zoom and Position of Traces

Data for display is not transformed to screen picture coordinates in a fixed way. These data is passing a bit slice processor (2903) which serves as an image manipulating unit. Position and scale of a trace may be changed or adapted ("shifter" or "zoomed") in both X and Y directions with no restrictions. This allows to compare signals that has been recorded primarly with different settings of attenuation and sample rate. This feature has to be understood as graphic possibility. PM3360 screen has a resolution of 320 picture elements (pixels) in X- and 256 pixels in Y-direction respectively, with the origin of this coordinate system at 160/138 pixels in the mentioned directions from the upper left corner of the screen picture. One has to be aware that position changes are made with respect to this origin. This means, X-position of the cursor of the selected trace and Y-position of base line of the selected trace have to be considered with respect to this coordinate system origin (Fig. 4.69).
Therefore, if one performs position changing in X-direction, one shifts the cursor and with it the whole trace. Because of the cursors position in a trace, which is given as an integer number with the same range as the recording length, the cursor forms the link between trace and channel in time direction. In Y-direction the base line is shifted with respect to the coordinate system and as the base line can be offsetted by the selectable offset voltage it forms the link between trace and channel in amplitude direction.

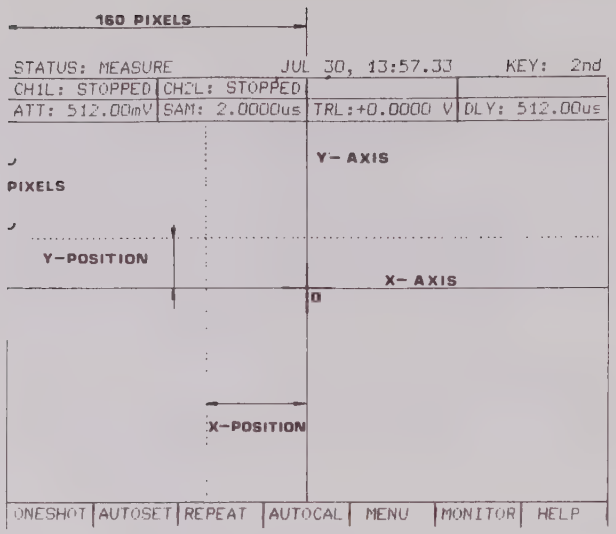


Fig. 4.69 Screen picture coordinate system

The cursor can be shifted from

-32 592 to + 32 502

in X-direction and the baseline can be shifted from

-32 647 to + 32 647

in Y-direction.

Zooming gives the possibility to expand or compress a trace in a wide range in X and Y-direction. An actual zooming action is described by a zooming factor. This zooming factor gives the number of recorded points visible on screen. Range of zooming in X-direction is

159 Number of points on screen 32 563

and in Y-direction

27 Number of points on screen 30 866

The numbers in Y-direction are valid for 12 bit converters, they are smaller by a factor of 16 for 8 bit-converters.

Be aware that traces defined as X/Y-represented are displayed around baseline and cursor of the"elements" and that actual zooms are used. Therefore it can be necessary to compress an X-Y picture appropriate.

Now one last point concerning display transformation in X-direction: If one e.g. has selected a recording length of 3200 points and the whole recording is displayed on the screen, then, of course, ten points will have the same X-coordinate. To avoid loss of information e.g. spikes between displayed points on screen the PM3360 system assigns all ten sampled amplitude values to this X-coordinate.

6. SPECIFICATIONS (Preliminary)

6.1 ENVIRONMENTAL

AMBIENT TEMPERATURE

Rated range of use (no floppy)	+ 5 ... +40 deg.C
Rated range of use (floppy)	+10 ... +35 deg.C
Operating	0 ... +45 deg.C
Storage and transport	-40 ... +70 deg.C

RELATIVE HUMIDITY

Operating (non-condensing)	20 % ... 80 %

ATTITUDE

Operating	< 5 km
Non operating (storage and transport)	< 15 km

SAFETY

In accordance with	IEC 348 Class 1

6.2 GENERAL

POWER SUPPLY

Voltage Range /001 Euro	190 - 250 V
/003 USA	90 - 130 V
/004 UK	210 - 265 V
consumption (maximum configuration)	350 VA at nominal voltage 1.6 A for /001 EURO 3.0 A for /003 USA 1.5 A for /004 UK
frequency	50 or 60 Hz
DIMENSIONS WxHxD	44x22x62 cm
WEIGHT (maximum configuration)	32 kg
PROBE CALIBRATOR	Automatic probe-calibration 1:1 1:10 1:100 square wave for probe compensation
Levels (DC or 1 kHz)	0.0 V +/- 0.5 mV 0.8 V +/- 1.0 mV 1.6 V +/- 1.0 mV 3.2 V +/- 2.0 mV 6.4 V +/- 4.0 mV
Frequency	2 kHz
Accuracy of frequency	<50 ppm/year
output	short circuit protected

6.2

6.3 MAINFRAME INCLUDING TRIGGER MANAGER

CPU	8086 (general) 8086 (graphics) 8087 (arithmetic) 8089 (I/O) 2903 (display-management)
SYSTEM MEMORY RAM (ref. mem)	128 kB
RAM (work. mem.)	256 kB
ROM	up to 320 kB
DATA TRANSFER FROM ALL INPUTS	< 20 msec
DISPLAY	
Type	9" color video RGB-monitor
Resolution	320 x 256 pixels
total acc. voltage	22.5 kV
COLORS	8 (BLACK inclusive)
TRACES	10
X-ZOOM	159 < points > 32563
Y-ZOOM	27 < points > 30866
POSITION	X and Y cont. adjustable traces overlapping without restrictions
DISPLAY-MODES	Y/t and X/Y
TRIGGER SOURCE	4 internal 1 external 1 line 2 soft
EXTERNAL ARMING	maskable
absolute max rate	-1.0 ... +7.0 V
EXTERNAL TRIGGERING	
range	+/-4.096 V or +/-65.536 V
resolution	8 bit
bandwidth	5 MHz (?)
input impedance	??? MOhm // ??? pF

over voltage protection	
DC-100 Hz	400 V
100 Hz-100 kHz	400 V -> 12 V
100 kHz	12 V
coupling	AC (22 msec; 7 Hz) / DC
LINE TRIGGERING	zero crossing level
TRIGGER CONDITIONS	combinational trigger and single trigger by logic functions up to complex boolean expressions
Trigger time	rising edge
Trigger pulse	falling edge
TRIGGER OUT CONDITIONS	Free choice
output	short circuit protected

6.4. INPUT MODULE PM3361

ELECTRICAL CHARACTERISTICS

number of channels	2
Resolution	8 bit
Sample rate	max 10 MHz 100 nsec to 6.55 msec in 100 nsec steps
Sample rate accuracy	< 50 ppm/year (5-40 degr. C)
Trace memory depth	max 4k words/channel
input impedance	1MOhm // <35 pF ??? pF +/- ??? pF
Analog bandwidth	5 MHz
Total non-linearity	+/-0.3 % +/-1 lsb
Input range	+/-64 mV to +/-65.536 V in 11 ranges
Offset range	100 % of full scale setting
Input coupling	AC (22 msec; 7 Hz) / GND / DC
Over voltage protection	
DC-100 Hz	400 V
100 Hz-100 kHz	400 V -> 12 V
100 kHz	12 V

6.5 INPUT MODULE PM3362

ELECTRICAL CHARACTERISTICS

Number of channels	2 differential
Resolution	12 bit
Sample rate	max 1 MHz 1 usec to 65.5 msec in 1 usec steps
Sample rate accuracy	< 50 ppm/year (5-40 degr. C)
Trace memory depth	max 4k words/channel
CMRR	???
Input-impedance	1 MOhm // <50 pF ???pF +/- ???pF
Analog bandwidth	500 kHz
Total non-linearity	+/-0.2 % +/-1 lsb
Input range	+/-256 mV to +/-65.536 V in 9 ranges
Offset range	100 % of full scale setting
Input coupling	AC (22 msec; 7 Hz) / GND / DC
Over voltage protection	
DC-100 Hz	400 V
100 Hz-100 kHz	400 V -> 12 V
100 kHz	12 V

6.6 INPUT MODULE PM3363

ELECTRICAL CHARACTERISTICS

Number of channels	1
Resolution	8 bit
Sample rate	max 50 MHz 20 nsec to 1.31 msec in 20 nsec steps
Sample rate accuracy	< 50 ppm/year
Trace-memory-depth	max 16k words/channel
Input-impedance	1 MOhm // 25 pF +/- ???pF
Analog Bandwidth	12.5 MHz
Total non-linearity	+/-1.0 % +/-1.0 lsb
Input range	+/-64mV to +/-65.536 V in 11 ranges
Offset range	100 % of full scale setting
Input coupling	AC (222 msec; 7 Hz) / GND / DC
Over voltage protection	
DC-100 Hz	400 V
100 Hz-100 kHz	400 V -> 12 V
100 kHz	12 V